JC18 Rec'd PCT/PTO 18 JUN 2001

| FORM PTO-1390 (REV 10-94) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE | | ATTORNEY'S DOCKET NUMBER 3961.47USWO |
|---|---|---|
| **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371** | | U S APPLICATION NO (If known, see 37 C F R 1 5) UNKNOWN 09/868462 |
| INTERNATIONAL APPLICATION NO. PCT/AU99/01127 | INTERNATIONAL FILING DATE 17 December 1999 | PRIORITY DATE CLAIMED 18 December 1998 |

TITLE OF INVENTION

SHOCK ABSORBER

APPLICANT(S) FOR DO/EO/US

Richard BUGAJ

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(l).
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [X] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [X] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [X] An unsigned oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11. to 16. below concern document(s) or information included:**

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
    [ ] A SECOND of SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information: International Preliminary Examination Report

JC03 Rec'd PCT/PTO 18 JUN 2001

| U.S. APPLICATION NO. (If known, see 37 C F R 1 5) | INTERNATIONAL APPLICATION NO | ATTORNEY'S DOCKET NUMBER |
|---|---|---|
| UNKNOWN 09/868462 | PCT/AU99/01127 | 3961.47USWO |

17. [X] The following fees are submitted:

**BASIC NATIONAL FEE (37 CFR 1.492(a) (1)-(5)):**

Search Report has been prepared by the EPO or JPO .......... **$860.00**

International preliminary examination fee paid to USPTO (37 CFR 1.492(a)(1)) .......... **$690.00**

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) .......... **$710.00**

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(3)) paid to USPTO .......... **$1000.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) .......... **$100.00**

**CALCULATIONS** | **PTO USE ONLY**

| | | | | CALCULATIONS | PTO USE ONLY |
|---|---|---|---|---|---|
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | | | | $1000.00 | |
| Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | | | | $ | |
| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | |
| Total claims | 51 -20 = | 31 | X **$18.00** | $ 558.00 | |
| Independent claims | 3 -3 = | | X **$80.00** | $ | |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | + **$260.00** | $ | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $1558.00 | |
| Reduction by 1/2 for filing by small entity, if applicable. Small entity status is claimed pursuant to 37 CFR 1.27 | | | | $ 779.00 | |
| **SUBTOTAL =** | | | | $ 779.00 | |
| Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f). + | | | | $ | |
| **TOTAL NATIONAL FEE =** | | | | $ 779.00 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property + | | | | $ | |
| **TOTAL FEES ENCLOSED =** | | | | $ 779.00 | |
| | | | | **Amount to be: refunded** | $ |
| | | | | **charged** | $ |

a. [X] Check(s) in the amount of $779.00ver the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _______________ in the amount of $ ___________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-2725.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**


SEND ALL CORRESPONDENCE TO
Brian H. Batzli
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P.O. Box 2903
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SIGNATURE: [signature]

NAME: Brian H. Batzli

REGISTRATION NUMBER: 32,960

S/N unknown

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | | |
|---|---|---|---|
| Applicant: | Richard BUGAJ | Docket No.: | 3961.47USWO |
| Serial No.: | unknown | Filed: | concurrent herewith |
| Int'l Appln No.: | PCT/AU99/01127 | Int'l Filing Date: | 17 December 1999 |
| Title: | SHOCK ABSORBER | | |

CERTIFICATE UNDER 37 CFR 1.10
'Express Mail' mailing label number: EL669942521US
Date of Deposit: 18 June 2001
I hereby certify that this correspondence is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C . 20231.

By: Omesh Singh
Name: Omesh Singh

**PRELIMINARY AMENDMENT**

Box PCT
Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Sir:

In connection with the above-identified application filed herewith, please enter the following preliminary amendment which is based on claims amended in prosecution of the international application and published in the International Preliminary Examination Report, a copy of which is enclosed herewith:

IN THE ABSTRACT

Insert the attached Abstract page into the application as the last page thereof.

IN THE SPECIFICATION

A courtesy copy of the originally-filed PCT specification is enclosed herewith, but the World Intellectual Property Office (WIPO) copy should be relied upon if it is already in the U.S. Patent Office.

## REMARKS

A new abstract page is supplied to conform to that appearing on the publication page of the WIPO application, but the new Abstract is typed on a separate page as required by U.S. practice.

Applicant respectfully requests that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicant's primary attorney-of record, Brian H. Batzli (Reg. No. 32,960), at (612) 336.4755.

Respectfully submitted,

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Dated: 18 June 2001

By ____________________
Brian H. Batzli
Reg. No. 32,960

BHB/klj

3961.47USWO


## ABSTRACT

A shock absorber comprises first and second axially aligned cylinders (11, 21) each having a liquid filled piston chamber (12, 22), an axially displaceable piston (13, 23) received in the piston chamber (12, 22), and means (14, 24) for dampening axial displacement of the piston (13,23) through the liquid in the piston chamber (12, 22). A piston rod (1) axially extends between and into the first and second cylinder piston chambers (12, 22). The first and second axial ends (1a, 1b) of the piston rod (1) are connected to the first and second cylinder pistons (13, 23) respectively.

16 PRTS

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JC03 Rec'd PCT/PTO 18 JUN 2001



# SHOCK ABSORBER

## Technical Field

The present invention relates to shock absorbers, and in particular relates to, but is not limited to shock absorbers for motor vehicles.

## Background of the Invention

Currently available hydraulic vehicle shock absorbers are most typically of the telescopic type in the form of a single piston and cylinder arrangement used in combination with a coil spring over the shock absorber. A piston rod is connected to the piston within the cylinder with its free end protruding from the cylinder for attachment to the body of the vehicle. The cylinder is attached to the vehicle wheel suspension. Extension or compression of the shock absorber, caused when the wheel suspension passes over a rough surface to elastically deform the coil spring, is damped by resistance to movement of the piston within the oil filled cylinder. The damping resistance to movement of the piston is provided by any of various forms of valve mechanism on the piston which restrict flow of the oil from one side of the piston to the other inside the cylinder.

The damping characteristics of the shock absorber can be adjusted to some degree through adjustment of the piston valve mechanism. Gas shock absorbers are also available which have the same basic structure outlined above, but are further provided with a gas chamber toward the end of the cylinder distal from the piston rod and separated from the oil filled chamber by an axially displaceable dividing piston. The gas pressure in the gas chamber can be adjusted to effect the dampening characteristics of the shock absorber.

These forms of currently available shock absorber suffer from various setbacks including limitations in adjustability to provide precise damping over specific ranges of wheel suspension movement amplitude and duration / frequency. The quality of ride provided by such shock absorbers is also typically compromised against vehicle handling performance.

## Object of the Invention

It is the object of the present invention to provide an improved shock absorber.

## Summary of the Invention

There is disclosed herein a shock absorber comprising:

first and second axially aligned cylinders each having a liquid filled piston chamber, an axially displaceable piston received in said piston chamber, and means for dampening axial displacement of said piston through said liquid in said piston chamber,

a piston rod axially extending between and into said first and second cylinder piston chambers, first and second axial ends of said piston rod being connected to said first and second cylinder pistons, respectively, and

means for securing said first and second cylinders to a body and wheel suspension of a vehicle, respectively.

In one embodiment at least one of said first and second cylinders is provided with a sealed gas chamber at an end thereof distal to said piston rod and preferably a valve means for adjusting gas pressure in said gas chamber, said piston and gas chambers being separated by an axially displaceable dividing piston.

Each of said at least one gas chamber may be disposed externally of the respective said cylinder, said gas chamber being disposed in a separate gas cylinder housing said dividing piston, said piston chamber communicating with said gas cylinder via a conduit at said distal end of said cylinder.

Both said first and second cylinders may be provided with a said sealed gas chamber and a said valve means.

The shock absorber may be provided with first and second coil springs, said first coil spring being associated with said first cylinder and having a first end axially fixed with respect to said piston rod and a second end axially fixed with respect to said first cylinder, said second coil spring being associated with said second cylinder and having a first end axially fixed with respect to said piston rod and a second end axially fixed with respect to said second cylinder.

The coil spring second ends may be fixed to the vehicle chassis and suspension respectively so as to fix their axial positions with respect to the first and second cylinders respectively.

Preferably said first and second coil spring first ends are axially fixed with respect to said piston rod by means of an annular end plate fixed to said piston rod between said first and second cylinders.

Alternatively the shock absorber may be associated with a single coil spring.

Preferably said shock absorber further comprises a sleeve extending between said first and second cylinders, axial ends of said sleeve sealingly engaging said first and second cylinders so as to define a sleeve cavity therebetween, said sleeve being telescopically displaceable with respect to at least one of said first and second cylinders to allow for relative axial displacement of said first and second cylinders. The sleeve may be provided with a valve means for adjusting gas pressure within said cavity.

Preferably said sleeve is axially displaceable with respect to both of said first and second cylinders.

Preferably a first annular cavity is defined in an overlap region between said first cylinder and said sleeve, opposing axial ends of said first annular cavity being respectively defined by a first seal means fixed to said first cylinder and sealingly engaging said sleeve and a second seal means fixed to said sleeve and sealingly engaging said first cylinder.

In one embodiment said first annular cavity communicates with said first piston chamber, a cross sectional area of said first annular cavity measured in a plane perpendicular to the axial direction being substantially equal to a cross sectional area of said piston rod.

Alternatively, the first annular cavity may be provided with a valve means for adjusting gas pressure therein.

Preferably a second annular cavity is defined in an overlap region between said second cylinder and said sleeve, opposing axial ends of said second annular cavity being respectively defined by a first seal means fixed to said second cylinder and sealingly

engaging said sleeve and a second seal means fixed to said sleeve and sealingly engaging said second cylinder.

In one embodiment said second annular cavity communicates with said second piston chamber, a cross-sectional area of said second annular cavity measured in a plane perpendicular to the axial direction being substantially equal to a cross sectional area of said piston rod.

Alternatively the second annular cavity may be provided with a valve means for adjusting gas pressure therein.

The shock absorber may be provided with first and second coil springs, said first coil spring being associated with said first cylinder and having a first end axially fixed with respect to said sleeve and a second end axially fixed with respect to said first cylinder, said second coil spring being associated with said second cylinder and having a first end axially fixed with respect to sleeve and a second end axially fixed with respect to said second cylinder.

The coil spring second ends may be fixed to the vehicle chassis and suspension respectively so as to fix their axial positions with respect to the first and second cylinders respectively.

Preferably said first and second coil spring first ends are axially fixed with respect to said sleeve by means of an annular end plate fixed to said sleeve between said first and second cylinders.

Alternatively the shock absorber may be associated with a single coil spring.

In one embodiment the first sealed annular cavity is filled with liquid, said first annular cavity being operatively associated with the sleeve cavity of another second said shock absorber such that a decrease/increase in the volume of said first annular cavity provides an increase/decrease in gas pressure in said sleeve cavity of said another shock absorber.

Preferably said first annular cavity communicates with a first end of a control cylinder and said sleeve cavity of said another shock absorber communicates with a second end of said control cylinder, a control cylinder dividing piston disposed within

said control cylinder isolating said first annular cavity and said sleeve cavity of said another shock absorber.

Preferably said control cylinder dividing piston is provided with a piston rod sealingly received in a reduced cross section portion of said control cylinder toward said control cylinder first end such that an extending end of said piston rod isolates said first annular cavity.

Preferably the first annular cavity of said another shock absorber is filled with liquid, said sealed annular cavity of said another shock absorber being operatively associated with the sleeve cavity of said shock absorber such that a decrease/increase in the volume of said first annular cavity of said another shock absorber provides an increase/decrease in gas pressure in said sleeve cavity of said another shock absorber.

There is further disclosed herein a shock absorber comprising:

a cylinder having a liquid filled piston chamber,

first and second axially displaceable pistons received in said piston chamber towards first and second respective ends of said cylinder,

means for dampening axial displacement of each of said first and second pistons through said liquid in said piston chamber,

a first piston rod connected to said first piston and extending through said cylinder first end,

a second piston rod connected to said second piston and extending through said cylinder second end, and.

means for securing said first and second piston rods to a body and wheel suspension of a vehicle, respectively.

Preferably said piston chamber is divided into first and second sub-chambers by a sealed gas chamber, said gas chamber being separated from said first and second piston sub-chambers by axially displaceable dividing pistons, said first and second pistons being received in said first and second piston sub-chambers, respectively, said gas chamber being provided with a valve means for adjusting gas pressure in said gas chamber.

Alternately said piston chamber is divided into first and second sub-chambers by a fixed seal, said first and second pistons being received in said first and second piston sub-chambers.

Said first and second sub-chambers may communicate with opposing ends of a gas cylinder via first and second conduits disposed adjacent said fixed seal in said first and second sub-chambers, respectively, said gas cylinder being provided with a gas chamber separated from said first and second conduits by axially displaceable dividing pistons.

The shock absorber may be provided with first and second coil springs, said first coil spring being associated with said first piston rod and having a first end axially fixed with respect to said cylinder and a second end axially fixed with respect to said first piston rod, said second coil spring being associated with said second piston rod and having a first end axially fixed with respect to said cylinder and a second end axially fixed with respect to said second piston rod.

The coil spring second ends may be fixed to the vehicle chassis and suspension respectively so as to fix their axial positions with respect to the first and second piston rods respectively.

Preferably said first and second coil spring first ends are axially fixed with respect to said cylinder by means of an annular end plate fixed to said cylinder.

Alternatively the shock absorber may be associated with a single coil spring.

Preferably said shock absorber further comprises a first sleeve telescopically disposed about and sealingly engaging said cylinder and extending from said cylinder first end, a distal axial end of said first sleeve being sealed such that said first sleeve defines a first sleeve cavity, said first piston rod being fixed in relation to said first sleeve. The first sleeve may be provided with a valve means for adjusting gas pressure within said first sleeve cavity.

Preferably a first annular cavity is defined in an overlap region between said cylinder and said first sleeve, opposing axial ends of said annular cavity being respectively defined by a first seal means fixed to said cylinder and sealingly engaging said first sleeve and a second seal means fixed to said first sleeve and sealingly engaging said cylinder.

In one embodiment said first annular cavity communicates with said first sub-chamber, a cross sectional area of said first annular cavity measured in a plane perpendicular to the axial direction being substantially equal to a cross sectional area of said first piston rod.

Preferably said first annular cavity is provided with a valve means for adjusting gas pressure within said first annular cavity.

Preferably said shock absorber further comprises a second sleeve telescopically disposed about and sealingly engaging said cylinder and extending from said cylinder second end, a distal axial end of said second sleeve being sealed such that said second sleeve defines a second sleeve cavity, said second piston rod being fixed in relation to said second sleeve. The second sleeve may be provided with a valve means for adjusting gas pressure within said second sleeve cavity.

Preferably a second annular cavity is defined in an overlap region between said cylinder and said second sleeve, opposing axial ends of said annular cavity being respectively defined by a first seal means fixed to said cylinder and sealingly engaging said second sleeve and a second seal means fixed to said second sleeve and sealingly engaging said cylinder.

In one embodiment said second annular cavity communicates with said second sub-chamber, a cross sectional area of said second annular cavity measured in a plane perpendicular to the axial direction being substantially equal to a cross sectional area of said first piston rod.

Preferably said second annular cavity is provided with a valve means for adjusting gas pressure therein.

In one embodiment said first annular cavity is filled with liquid, said first annular cavity being operatively associated with the first sleeve cavity of another second said shock absorber such that a decrease in the volume of said first annular cavity provides an increase in gas pressure in said first sleeve cavity of said another shock absorber.

Preferably said first annular cavity communicates with a first end of a control cylinder and said first sleeve cavity of said another shock absorber communicates with a second end of said control cylinder, a control cylinder dividing piston disposed within

said control cylinder isolating said first annular cavity and said first sleeve cavity of said another shock absorber.

Preferably said control cylinder dividing piston is provided with a piston rod sealingly received in a reduced cross section portion of said control cylinder toward said control cylinder first end such that an extending end of said piston rod isolates said first annular cavity.

Preferably the first annular cavity of said another shock absorber is filled with liquid, said first annular cavity of said another shock absorber being operatively associated with the first sleeve cavity of said shock absorber such that a decrease in the volume of said first annular cavity of said another shock absorber provides an increase in gas pressure in said first sleeve cavity of said another shock absorber.

There is further disclosed herein a shock absorber comprising:

a cylinder having a liquid filled piston chamber,

an axially displaceable piston received in said piston chamber,

means for dampening axial displacement of said piston through said liquid in said piston chamber,

a piston rod connected to said piston and extending through a first end of said cylinder,

a sleeve telescopically disposed about and sealingly engaging said cylinder and extending from said cylinder first end, a distal axial end of said sleeve being sealed such that said sleeve defines a sealed sleeve cavity, said piston rod being fixed in relation to said sleeve, and

means for securing one of said sleeve and said cylinder to a body of a vehicle and the other of said sleeve and said cylinder to a wheel suspension of a vehicle.

The sleeve may be provided with a valve means for adjusting gas pressure within said sleeve cavity.

Preferably an annular cavity is defined in an overlap region between said cylinder and said sleeve, opposing axial ends of said annular cavity being respectively defined by a first seal means fixed to said cylinder and sealingly engaging said sleeve and a second seal means fixed to said sleeve and sealingly engaging said cylinder.

In one embodiment said annular cavity communicates with said piston chamber, a cross sectional area of said annular cavity measured in a plane perpendicular to the axial direction being substantially equal to a cross sectional area of said piston rod.

Preferably said annular cavity is provided with a valve means for adjusting gas pressure therein.

In one embodiment said annular cavity is filled with liquid, said annular cavity being operatively associated with the sleeve cavity of another second said shock absorber such that a decrease/increase in the volume of said annular cavity provides an increase/decrease in gas pressure in said sleeve cavity of said another shock absorber.

Preferably said annular cavity communicates with a first end of a control cylinder and said sleeve cavity of said another shock absorber communicates with a second end of said control cylinder, a control cylinder dividing piston disposed within said control cylinder isolating said annular cavity and said sleeve cavity of said another shock absorber.

Preferably said control cylinder dividing piston is provided with a piston rod sealingly received in a reduced cross section portion of said control cylinder toward said control cylinder first end such that an extending end of said piston rod isolates said annular cavity.

Preferably the annular cavity of said another shock absorber is filled with liquid, said annular cavity of said another shock absorber being operatively associated with the sleeve cavity of said shock absorber such that a decrease in the volume of said annular cavity of said another shock absorber provides an increase in gas pressure in said sleeve cavity of said another shock absorber.

## Brief Description of the Drawings

Preferred forms of the present invention will now be described by way of example with reference to the accompanying drawings wherein:

Figure 1 is a sectional front elevation view of a shock absorber according to a first embodiment in an extended state.

Figure 2 is a sectional front elevation view of the shock absorber of Figure 1 in a compressed state.

Figure 1a is a sectional front elevation view of a shock absorber according to a version of the first embodiment in an extended state.

Figure 2a is a sectional front elevation view of the shock absorber of Figure 1a in a compressed state.

Figure 3 is a sectional front elevation view of a shock absorber according to a further version of the first embodiment in an extended state.

Figure 4 is a sectional front elevation view of a shock absorber according to a modified first embodiment in an extended state.

Figure 5 is a sectional front elevation view of a shock absorber according to a second embodiment in an extended state.

Figure 6 is a sectional front elevation view of a shock absorber according to a first embodiment in a compressed state.

Figure 7 is a sectional front elevation view of a shock absorber according to a modified second embodiment in an extended state.

Figure 8 is a sectional front elevation view of an alternative form of the shock absorber of Figure 3 in an extended state.

Figure 9 is a sectional front elevation view of an alternative form of the shock absorber of Figure 7 in an extended state.

Figure 10 is a sectional front elevation view of a modified form of the shock absorber of Figure 1 in an extended state.

Figure 11 is a sectional front elevation view of a modified form of the shock absorber of Figure 5 in an extended state.

Figure 12 is a sectional front elevation view of a shock absorber according to a further modified second embodiment in a compressed state.

Figure 13 is a sectional front elevation view of the shock absorber of Figure 12 in an extended state.

Figure 14 is a sectional front elevation view of a shock absorber according to a third embodiment in an extended state.

Figure 15 is a sectional front elevation view of the shock absorber of Figure 14 in a compressed state.

Figure 16 is a sectional front elevation view of a modified form of the shock absorber of Figure 7 in a compressed state.

Figure 17 is a sectional front elevation view of the shock absorber of Figure 16 in an extended state.

Figure 18 is a sectional front elevation view of two operatively associated shock absorbers according to Figure 12.

Figure 19 is a sectional front elevation view of an arrangement similar to that of Figure 18.

Figure 20 is a sectional front elevation view of an arrangement similar to that of Figure 19 but utilising two shock absorbers according to Figure 16.

Figure 21 is a sectional front elevation view of a modified form of the shock absorber of Figure 14 in an extended state.

Figure 22 is a sectional front elevation view of the shock absorber of Figure 21 in a compressed state.

Figure 23 is a sectional front elevation view of a modified form of the shock absorber of Figure 16 in a compressed state.

Figure 24 is a sectional front elevation view of the shock absorber of Figure 23 in an extended state.

Figure 25 is a sectional front elevation view of a McPherson type version of the shock absorber of Figure 23 in a compressed state.

Figure 26 is a sectional front elevation view of a shock absorber similar to that of Figure 25 in an extended state.

## Detailed Description of the Preferred Embodiments

Figures 1 and 2 depict a shock absorber according to a first embodiment in extended and compressed states. The shock absorber is provided with first and second axially aligned cylinders 11, 21. Each of the cylinders is provided with a piston chamber 12, 22 which is filled with oil, hydraulic fluid or any other suitable liquid in the usual manner.

Axially displaceable pistons 13, 23 are received in each of the first and second piston chambers 12, 22, along with means for dampening axial displacement of the pistons 13, 23 through the liquid in the respective piston chambers 12, 22.

The dampening means may take any suitable form as are known in the art. A typical dampening means would be a common valve mechanism 14, 24 on the pistons 13, 23 which comprises one or more apertures 14a, 24a passing through the axial extent of the piston 13, 23 and a series of flexible thin plates 14b, 24b secured to the axial ends of the piston which at least partially cover the aperture(s) 14a, 24a to restrict or block the passage of oil therethrough. Deformation of the plates away from the aperture(s) as a result of liquid pressure enables liquid flow through the apertures.

A piston rod 1 axially extends between the first and second cylinders 11, 21 and into the first and second cylinder piston chambers 12, 22. The first and second axial ends 1a, 1b of the piston rod 1 are connected to the first and second cylinder pistons 14, 24, respectively, in the usual manner.

A threaded rod 15 extends from the upper end 11a of the first cylinder distal to the piston rod 1 for securing the first cylinder to a mounting point on the body of a vehicle (not shown) in the usual manner. Other means for securing the first cylinder could also be utilised as required to suit the specific vehicle. A bearing 25 is formed at the distal or lower end 21a of the second cylinder 21 for securing the second cylinder to the wheel suspension of the vehicle (not shown) in the usual manner. Again the means for securing the second cylinder may be of any form suited to the specific wheel suspension.

The proximal ends 11b, 21b of the cylinders are each provided with an end piece and guide with seal 19, 29 for sealing the end of the pistons chambers at the point of entry of the piston rod 1.

A coil spring can be used with the shock absorber in the usual manner.

The shock absorber according to the first embodiment is thus in the general form of two opposing standard shock absorbers joined by their piston rods. Having two pistons to effect the dampening in a single shock absorber increases the available dampening for a given shock absorber and a reduction by half of the travel of each piston and the piston rod. This provides reduced operating temperatures and pressures and an extended life for

the shock absorber. Damping can also effectively be provided for even short duration and low amplitude wheel movements. The twin piston design also enables the shock absorber to dampen from 50% to perhaps 100% higher frequencies than a single piston design. There is also the possibility to increase the total piston area by up to 100% as compared to a single cylinder shock absorber with the same cylinder diameter.

Whilst in a standard single piston shock absorber the moving piston is directly coupled to the vehicle, the described twin piston shock absorber isolates the moving pistons from both the vehicle body and wheel suspension via the oil within the piston chambers. This isolation, and the reduction in displacement amplitude provides improved level of ride comfort to the occupants of the vehicle.

Having two pistons also provides for adjustment of two valve mechanisms, such that increased adjustment to the damping characteristics can be carried out. Further the valve mechanisms of the two pistons can be adjusted to provide individually different characteristics, tuning the shock absorber to two distinct ranges of wheel vibration / displacement. Such twin range tuning could be particularly beneficial for rally cars which may be subject to rough dirt roads and bitumen within one race stage, requiring different shock absorber characteristics. Separate coils of different stiffness could also be used over each cylinder.

As per any standard shock absorber, axial displacement of the pistons 13, 23 within the piston chamber 12, 22 will result in the axial ends 1a, 1b of the piston rod 1 extending into and retracting from the piston chambers 13, 23, varying the available volume of the piston chambers 13, 23 for the liquid therein. This may be compensated for in any of several standard manners, enabling the pistons to axially displace without the incompressible liquid in the piston chamber 13, 23 preventing extension of the piston rod 1 into the piston chamber 13, 23. The most simple manner of providing this compensation is to provide a small pocket of gas at the end of each piston chamber 13, 23, the gas compressing when the piston rod 1 enters the chamber and expanding on withdrawal. This method is not preferred, however, as mixing of the liquid and gas in the piston chamber occurs. A small plastic bag filled with gas can be provided in each piston chamber 13, 23 to compensate for this problem.

A more preferred standard method of compensating is depicted in Figures 1a and 2a, based on a standard "twin tube" type shock absorber. An external tube 11a, 21a surrounds each of the piston cylinders 11, 21 and defines an annular compensation cavity 12a, 22a communicating with the piston chamber 12, 22. The annular compensation cavities are each largely filled with gas. Compression of the shock absorber extends the piston rod 1 into the piston chambers 13, 23 and displaces liquid into the annular compensation cavities 12a, 22a, compressing the gas therein in the usual manner.

An alternative gas shock absorber form of the first embodiment, utilising another standard method of compensating for extension of the piston rod 1 into the piston chambers 13, 23, is depicted in Figure 3. Sealed gas chambers 16, 26 are provided at the distal ends 11a, 21a of the first and second cylinders. Valves 17, 27 may be provided in the usual manner for adjusting gas pressure within the gas chambers 16, 26. The gas chambers 16, 26 are separated from the respective piston chambers 12, 22 by axially displaceable dividing pistons 18, 28 which are free floating and enable the pressure within the gas chamber to be transmitted to the liquid within the piston chambers 12, 22. Rather than both cylinders being provided with the separate gas chamber 16, 26, it is envisaged that only one of the cylinders might have a separate gas chamber 16, 26. It is further envisaged that the gas supply for the gas chambers could be stored externally of the cylinders and communicated with the gas chambers 16, 26 via hose or similar.

Provision of the gas chambers provides the capability for further adjustment of the damping characteristics at each piston and the overall characteristics of the shock absorber.

It will be appreciated by the person skilled in the art that each of the shock absorbers described herein will be provided with any of the standard configurations for enabling axial displacement of the pistons by compensating for extension and retraction of the piston rod(s) into and from the piston chamber(s).

A further modification of the first embodiment shock absorber is depicted in Figure 4. A sleeve 31 is provided which extends between the first and second cylinders 11, 21. Axial ends 31a, 31b of the sleeve 31 sealingly engage the first and second cylinders 11, 21 so as to define a sealed cavity 32 therebetween. The sleeve ends typically sealingly

engage the outer wall of the cylinders via sealing rings 33, 33 which enable the sleeve to be axially displaceable along the outer walls of the cylinders, allowing relative axial displacement of the first and second cylinders 11, 21 during compression and expansion of the shock absorber. It is also envisaged that the sleeve may be fixed to one of the cylinders and axially displaceable with respect to the other so as to still enable expansion and compression of the shock absorber. A detent 34 is provided on each cylinder to ensure the sealing engagement of the sleeve and cylinders is maintained without the sleeve 31 sliding off the end of either cylinder.

Provision of the sleeve 31 improves the lateral stiffness of the shock absorber, and provides further opportunity to adjust the damping characteristics of the shock absorber. Increasing the pressure within the cavity 32 will increase the length of the shock absorber so as to elevate the vehicle if required. The increased pressure will also render the shock absorber harder to compress and easier to extend. A reduced pressure in the cavity will decrease the length of the shock absorber, lowering the vehicle, and making the shock absorber easier to compress and harder to extend.

Figures 5 and 6 depict a second embodiment of a shock absorber in extended and retracted states, respectively. The shock absorber comprises a single cylinder 111 with a liquid filled piston chamber 112. First and second axially displaceable pistons 113, 123 are received in the sealed piston chamber 112 towards first and second respective ends 111a, 111b of the cylinder. As per the first embodiment, any of various valve mechanisms 114, 124 or other known means may be provided for dampening axial displacement of each of the first and second pistons 113, 123 through the liquid in the piston chamber 112.

A first piston rod 101 is connected to the first piston 113 and extends through the cylinder first end 111a, whilst an equivalent second piston rod 201 is connected to the second piston 123 and extends through the cylinder second end 111b.

The first piston rod 101 is provided with a threaded portion 101a for securing the first piston rod 101 to a mounting point on the body of a vehicle, whilst the second piston rod 201 is provided with a bearing 202 for securing to the wheel suspension of the

vehicle. As per the first embodiment, other forms of attachment may be employed as required.

An end piece and guide with seal 19, 29 is provided at each end of the cylinder 111 as per the first embodiment.

A modification of the second embodiment is depicted in Figure 7 which produces a gas shock absorber. The piston chamber is divided into first and second sub-chambers 112a, 112b by a sealed gas chamber 116. The gas chamber 116 is separated from the first and second piston sub-chambers 112a, 112b by axially displaceable dividing pistons 118, 128 in mush the same manner as those of the first embodiment. A valve 117 will typically be provided to enable adjustment of the gas pressure within the gas chamber 116 thereby enabling further adjustment of the damping characteristics of the shock absorber.

As per the first embodiment, both versions of the second embodiment shock absorber increases the available dampening for a given shock absorber and a reduction by half of the travel of each piston and piston rod with the resultant advantages discussed above. Increased opportunity for adjustment and customising the damping characteristics of the shock absorber are also provided through the piston valve mechanisms and the gas chamber (of the Figure 7 modified embodiment).

An alternative to the shock absorber of Figure 3 is depicted in Figure 8. Rather than providing sealed gas chambers 16, 26 within the first and second cylinders 11, 21, gas chambers 16', 26' may be provided externally of the first and second cylinders 11, 21. The sealed gas chambers 16', 26' are each disposed in a separate gas cylinder 40, 50 housing the dividing piston 18, 28. The piston chambers 12, 22 communicate with the respective gas cylinder 40, 50 via a conduit 41, 51 at the distal end of the cylinder 11, 21. Such a configuration employing external gas cylinders 40, 50 enables a shorter overall shock absorber length as compared to the shock absorber of Figure 3.

A similar alternative to the shock absorber of Figure 7 is depicted in Figure 9. The piston chamber 112 is divided into first and second sub-chambers 112a, 112b by a fixed seal 145 fixed to the wall of the cylinder 111. The first and second sub-chambers 112a, 112b communicate with opposing ends of a gas cylinder 140 via first and second conduits

141, 151 adjacent the fixed seal 145. A gas chamber 116 is defined between axially displaceable dividing pistons 118, 128 provided in the gas cylinder 140.

It is also envisaged that the fixed seal 145 could be provided in a shock absorber without any gas chamber (such as the shock absorber of Figures 5 and 6). The fixed seal 145 will divide the piston chamber into first and second isolated sub-chambers 112. This will make the shock absorber effectively act as two separate shock absorbers connected end to end with no interaction therebetween. This configuration, whilst providing for separate adjustment of the two ends, will not be as smooth as a shock absorber which leaves the piston chamber as a single chamber (Figures 5 and 6) or a shock absorber which separates piston sub-chambers with a gas chamber (Figures 7 and 9).

Whilst the various shock absorbers of the present invention may be associated with only a single coil spring as per a standard shock absorber, with the spring top end fixed to the vehicle chassis and lower end fixed to the vehicle suspension, each shock absorber may be provided with two coil springs, one being associated with each end of the shock absorber.

The shock absorber of Figure 1 is depicted with two coil springs 60, 61 in Figures 10. A first coil spring 60 is associated with the first cylinder 11, and has a first end 60a axially fixed with respect to the piston rod 1. The second end 60b of the first coil spring is axially fixed with respect to the first cylinder 11. The coil spring second end 60b may either be axially fixed to the first cylinder 11, perhaps by a plate fixed to the first cylinder and abutting the spring end 60b, or may be axially fixed to the vehicle chassis / body about the point that the threaded rod 15 is fixed. The second coil spring 61 is associated with the second cylinder 21 and has its first and second ends 61a, 61b axially fixed in a similar manner. The second coil spring second end 61b will typically be fixed to the vehicle suspension. The coil spring first ends 60a, 61a are preferably axially fixed with respect to the piston rod 1 by means of an annular end plate 62 fixed to the piston rod 1 between the first and second cylinders 11, 21. The coil spring first ends 60a, 61a abut this annular plate 62 so as to fix their axial location with respect to the piston rod 1. The use of two coil springs in this manner allows the use of a different stiffness springs associated with each of the cylinders 11, 12. A first coil spring 60 of a given stiffness can thus be

coupled with the first cylinder 11 with predetermined damping characteristics, and a second coil spring 61 with a different given stiffness coupled with the second cylinder 12 with different damping characteristics.

The shock absorber of Figure 4 could be modified in a similar way with two coil springs 60, 61, with the plate 62 axially fixing the coil spring first ends 60a, 61a being fixed to the sleeve 31 rather than the piston rod 1.

The shock absorber of Figure 5 is depicted with two coil springs 60, 61 in Figure 11. The first coil spring 60 is associated with the first piston rod 101, and has a first end 60a axially fixed with respect to the cylinder 111. The second end 60b of the first coil spring is axially fixed with respect to the first piston rod 101. The coil spring second end 60b may either be axially fixed to the first piston rod 101, perhaps by a plate fixed to the first piston rod and abutting the spring end 60b, or may be axially fixed to the vehicle body about the point that the threaded end 101a is fixed. The second coil spring 61 is associated with the second piston rod 201 and has its first and second ends 61a, 61b axially fixed in a similar manner. The coil spring first ends 60a, 61a are preferably axially fixed with respect to the cylinder 111 by means of an annular end plate 162 fixed to the cylinder 111. The two coil spring arrangement can be applied in this manner to the shock absorbers of Figures 7 and 9.

The twin piston rod, single cylinder shock absorbers of Figures 5 through 7, 9 and 11 can be provided with a sleeve or sleeves in a similar manner to the single piston rod, twin cylinder shock absorbers of Figure 7. Such a modified shock absorber is depicted in Figures 12 and 13 in compressed and extended states, respectively.

A first sleeve 131 is telescopically disposed about and sealingly engages the cylinder 111 and extends from the cylinder first end 111a. The distal axial end 131b of the first sleeve 131 is sealed with an end wall such that the first sleeve 131 defines a sealed first sleeve cavity 132. The first piston rod 101 is fixed to the first sleeve such that axial displacement of the first piston rod 101 will provide an equal displacement of the first sleeve 131 and corresponding change in volume and pressure in the first sleeve cavity 132. A valve 138 will be provided in the first sleeve to enable adjustment of the gas pressure therein. A second sleeve 231 may be similarly mounted on the cylinder second

end 111b. Extension of the shock absorber, to the state of Figure 13, will increase the volume and consequently decrease the pressure in the first and second sleeve cavities 132, 232.

Increasing the gas pressure in the first sleeve cavity 132 via the valve 138 will increase the length of the shock absorber and render it harder to compress and easier to extend. The gas pressure in the second sleeve cavity 232 can also be adjusted to further adjust the characteristics of the shock absorber as desired.

Here the first sleeve 131 engages the cylinder 111 in such a manner that a first annular cavity 135 is defined in an overlap region between the first sleeve 131 and the cylinder 111. One axial end of the first sealed annular cavity 135 is defined by a first annular seal 133 which is fixed to the cylinder at its first end 111a and sealingly engages the first sleeve. The opposing axial end of the first sealed annular cavity 135 is defined by a second annular seal 134 which is fixed to the first sleeve 131 adjacent the proximal end 131a thereof and sealingly engages the cylinder 111. The first annular cavity will typically be provided with a valve 136 for adjusting gas pressure therein. A second sealed annular cavity 235 can similarly be provided at the second sleeve 231.

Provision of the sealed annular cavities 135, 235 provides for further adjustment effecting both the compression and extension (or rebound) strokes. Increasing the pressure in the first sleeve cavity 132 as compared to the first annular cavity 135 will increase the length of the shock absorber and increase the force required to compress the shock absorber whilst decreasing the force to extend the shock absorber. The same effect is achieved by reducing the pressure in the first annular cavity 135. Increasing pressure in the first annular cavity 135, or decreasing the pressure in the first sleeve cavity 132, will shorten the shock absorber. Different adjustments can be made to pressure in the second sleeve cavity 232 and second annular cavity 235 as desired. Additional adjustment opportunities will again be provided if two different stiffness coil springs are used with the shock absorber.

The piston chamber will preferably be separated into first and second piston sub-chambers by a fixed seal 145 and a gas cylinder 140 (as depicted in Figure 12) may be used to soften the shock absorber response as per the shock absorber of Figure 9.

The use of a sleeve 131 as described above and depicted in Figures 12 and 13 can also be employed with a standard single cylinder, single piston shock absorber, as depicted in Figures 14 and 15 in the extended and compressed states respectively. The sleeve 131 is mounted on the cylinder 311 in the same manner as either of the sleeves of the shock absorber of Figure 12, with the single piston rod 301 fixed to the sleeve 131. The sleeve 131 may engage the cylinder 311 so as to provide a sealed annular cavity 135, enabling adjustment of pressure in both the sleeve cavity 132 and the annular cavity 135, or the sleeve 131 may be mounted so as only to provide the sealed sleeve cavity 132.

Provision of annular cavities can also be achieved in a similar manner with the two cylinder, single piston rod sleeved shock absorber of Figure 4. Such a modified shock absorber is depicted in Figures 16 and 17 in the compressed and extended states respectively. A first sealed annular cavity 35 is defined in an overlap region between the first cylinder 11 and the sleeve 31. One axial end of the first annular cavity 35 is defined by a first annular seal 33 which is fixed to the first cylinder at its second end 11b and sealingly engages the sleeve 31. The opposing axial end of the first annular cavity 35 is defined by a second annular seal 37 which is fixed to the sleeve at its first end 31a and sealingly engages the first cylinder 11. The first sealed annular cavity 35 is typically provided with a valve 36 for adjusting gas pressure therein. A second sealed annular cavity 35' can be provided at the second cylinder 21 in the same manner.

Again using different pressures in the sleeve cavity 32 as compared to the first and/or second annular cavities 35, 35' provides for adjustment of characteristics of both the compression and extension strokes. Increasing the pressure in the sleeve cavity 32 will extend the shock absorber and can be used to level the vehicle when under heavy load. Increasing the pressure in the sleeve cavity 32 will also increase the force to compress the shock absorber and hence harden the compression stroke. Alternatively, increasing the pressure in the annular cavities 35, 35' will shorten the shock absorber and increase the force to extend the shock absorber, hardening the extension (or rebound) stroke.

The shock absorbers providing sealed sleeve cavities and sealed annular cavities, as depicted in Figures 12 to 17, can be communicated to balance the overall suspension of a vehicle. Figure 18 depicts two shock absorbers according to Figure 12 communicated in

such a way. The first sealed annular cavities 132 of each shock absorber are filled with liquid (typically oil), rather than gas as per the annular cavities of the stand-alone shock absorbers. There is no thus no need to provide gas pressure adjustment valves for the annular cavities. The first sealed annular cavity 132 of each shock absorber is operatively associated with the first sleeve cavity 135 of the other shock absorber such that an increase in the volume of the first sealed annular cavity 132 provides a reduction in gas pressure in the first sleeve cavity 135 of the other shock absorber. Conversely a decrease in volume of the first sealed annular cavity 132 of one shock absorber will provide an increase in gas pressure in the first sleeve cavity 135 of the other shock absorber.

To provide the above operative association the first sealed annular cavity 135 of one shock absorber communicates via a conduit 171 with a first end 172a of a control cylinder 172 and the first sleeve cavity 132 of the other shock absorber communicates via a conduit 175 with a second end 172b of the control cylinder 172. A control cylinder dividing piston 173 is disposed within the control cylinder 172 and isolates the associated first sealed annular cavity 135 and first sleeve cavity 132. The control cylinder dividing piston 173 is provided with a piston rod 174 which is housed in a reduced cross section tubular portion 172c of the control cylinder 172 toward the control cylinder first end 172a. The piston rod 174 and tubular portion 172c are sized such that the piston rod 174 seals the tubular portion 172c and the extending end 174a of the piston rod 174 consequently isolates the first sealed annular cavity 135 from the main chamber of the control cylinder housing the piston 173.

Operation of this arrangement will now be explained in relation to a cornering motor vehicle when the shock absorber on the left is compressed and the shock absorber on the right expands, as depicted in Figure 18. Expansion of the right shock absorber will reduce the volume of the first annular cavity of the right shock absorber, causing liquid in the first annular cavity 135 of the right shock absorber to be forced out of the first annular cavity 135 through the conduit 171 where it will apply a pressure on the relatively small area of the extended end 174a of the associated piston rod 174. This pressure will act to push the piston rod 174 against the gas on the opposing side of the piston 173 in the main chamber of the control cylinder 172, increasing the pressure of this gas which is

communicating with the first sleeve cavity 132 of the shock absorber on the left. This increase in pressure in the first sleeve cavity will in turn act to expand the shock absorber on the left, helping to restore it to its original position. Similarly compression of the left shock absorber will draw liquid into its expanding first annular cavity 135, drawing with it the associated piston rod 174 and reducing the gas pressure in the control cylinder main chamber and in the first sleeve cavity 132 of the right shock absorber. This reduction in pressure will act to compress the right shock absorber toward its original position. The interaction between the two shock absorbers on opposing sides of the vehicle will hence help to keep the vehicle level. The second sleeve cavity 232 and second annular cavity 235 can also be associated in the same way.

This arrangement can be used to associate the four shock absorbers of a motor vehicle in various ways. The front left and right shock absorber can be linked, with the rear left and right shock absorbers being linked independently. Alternatively the front left could be linked to the right rear, with the front right linked to the left rear. Provision of linkage at the first and second ends of the shock absorbers will enable a more complex network of linkages.

The balancing or levelling effect of the linkage between shock absorbers can be varied in magnitude by varying the relative area between the piston rod external end and the main piston area on which the gas acts.

Each of the shock absorbers of Figures 14 to 17 can also be operatively associated in the above manner, communicating the various sleeve cavities with the liquid filled annular cavity/ies of another shock absorber.

Figure 19 depicts the arrangement of Figure 18, with the piston chambers 112 of the left and right shock absorbers being associated via a gas cylinder 180. The piston chambers 112 communicate with opposing ends of the gas cylinder 180 via conduits 181. A gas chamber 182 is defined between two dividing pistons 183 housed in the gas cylinder 180. The gas cylinder 180 acts to compensate for extension of the pistons rods into the piston chambers 112 of each shock absorber and soften the action of the shock absorber as discussed above.

Figure 20 depicts an arrangement equivalent to that of Figure 19 utilising two twin cylinder, single piston rod sleeved shock absorbers as per Figure 16 and 17. Gas cylinders 180 associate the corresponding piston chambers 12, 22 of the left and right shock absorbers as discussed above. The sleeve cavity 32 of each shock absorber is associated with either or both of the first and second sealed annular cavities 35, 35' of the other shock absorber by a control cylinder 172 as discussed above in relation to the arrangement of Figure 18. The annular cavities so associated will be filled with liquid rather than gas. The annular cavity 35 or 35' communicates with the first end 172a of the control cylinder 172 via a conduit 171, whilst the sleeve cavity 32 communicates with the second end 172b of the control cylinder 172 via a conduit 175. The control cylinders 172 are provided with the same piston 173 and piston rod arrangement 174 as described above.

Operation of this arrangement is generally as per that of Figure 18. Expansion of the right shock absorber during cornering will force liquid from the annular cavity 35' into the control cylinder 172, and thereby increase the pressure in the sleeve cavity 32 of the left shock absorber, tending to expand the compressed left shock absorber. Similarly, compression of the left shock absorber as a result of the cornering will draw liquid into its annular cavity 35' from the associated control cylinder 172, and thereby decrease the pressure in the sleeve cavity 32 of the right shock absorber, tending to compress the expanded right shock absorber.

As discussed above, during extension and compression of any shock absorber, axial displacement of the piston(s) within the piston(s) chamber will result in the piston rod(s) extending into and retracting from the piston chamber(s), varying the available volume of the piston chamber(s) for the liquid therein. The shock absorbers depicted in Figures 21 through 26 provide another alternate means of compensating for this variation in volume of the piston chamber(s) utilizing several of the shock absorber arrangements described herein.

Figures 21 and 22 depict a shock absorber similar to that of Figures 14 and 15 but utilising the alternate compensation means. In this embodiment, rather than sealing and pressurising the annular cavity 135 defined in the overlap region between the sleeve 131

and cylinder 311, the annular cavity 135 is communicated with the piston chamber 312 via apertures 191 disposed adjacent the cylinder first end 311a. Oil fills both the piston chamber 312 and the annular cavity 135. The cross-sectional area of the annular cavity 135, as measured in a plane perpendicular to the longitudinal axis of the piston rod 301, is substantially equal to the cross sectional area of the piston rod 301. With this configuration, as the shock absorber is compressed and the piston rod 301 extends into the piston chamber 312, the reduction in volume of the piston chamber 312 is substantially identical to the increase in volume of the annular cavity 135, such that oil displaced by the piston rod 301 in the piston chamber 312 is accommodated by the increased volume of the annular cavity 135.

This configuration could also be applied to the twin piston rod configuration of Figures 12 and 13, with both the first and second annular cavities 135, 235 communicating with the respective piston sub-chambers.

Utilizing the annular cavity volume change to accommodate oil displaced by the piston rod avoids the requirement for a separate compressible gas chamber separated from the piston chamber by a dividing piston as described above. The absence of the pressurised gas chamber also avoids pressurisation of the hydraulic fluid or oil filling the piston chamber. Cavitation and aeration is also effectively eliminated.

The shock absorber configuration of Figures 16 and 17 can be modified in a similar manner to accommodate oil displaced by the piston rod. Such a modified shock absorber is depicted in Figures 23 and 24. Again here the first and second annular cavities 35, 35'communicate with the first and second piston chambers 12, 22 via apertures 191 adjacent the first and second cylinder second ends 11b, 21b respectively. Again the cross sectional area of the annular cavities 35, 35' are substantially equal to the cross sectional area of the piston rod 1.

The various embodiments of the present invention are applicable to McPherson strut type shock absorbers, with particular examples being depicted in Figures 25 and 26. The embodiment of Figure 25 is identical to that of Figure 22, with the second cylinder first end 21a being secured to the leg 401 of the McPherson strut with the sleeve 31 of the shock absorber being longitudinally displaceable within the McPherson strut leg 401.

Another possible variation is depicted in Figure 26, which is identical to the shock absorber of Figure 25 except that the first cylinder 11 and annular cavity 35 are arranged as per the embodiment of Figure 16 and 17 without an aperture communicating the annular cavity 35 and first piston chamber. Accordingly, to provide for displacement of the piston rod 1 into the first piston chamber 12, a dividing piston 18 is provided in the first cylinder 11 separating the first piston chamber 12 from a gas chamber 16 in the usual manner.

Various other variations and combinations of features of the shock absorbers described will be apparent to the person skilled in the art.

I CLAIM:

1. A shock absorber comprising:

first and second axially aligned cylinders each having a liquid filled piston chamber, an axially displaceable piston received in said piston chamber, and means for dampening axial displacement of said piston through said liquid in said piston chamber.

a piston rod axially extending between and into said first and second cylinder piston chambers, first and second axial ends of said piston rod being connected to said first and second cylinder pistons, respectively, and

means for securing said first and second cylinders to a body and wheel suspension of a vehicle, respectively.

2. The shock absorber of claim 1 wherein at least one of said first and second cylinders is provided with a sealed gas chamber at an end thereof distal to said piston rod, said piston and gas chambers being separated by an axially displaceable dividing piston..

3. The shock absorber of claim 2 wherein each of said at least one gas chamber is provided with a valve means for adjusting gas pressure therein.

4. The shock absorber of claim 2 wherein each of said at least one gas chamber is disposed externally of the respective said cylinder, said gas chamber being disposed in a separate gas cylinder housing said dividing piston, the respective said piston chamber communicating with said gas cylinder via a conduit at said distal end of the respective said cylinder.

5. The shock absorber of claim 1 further comprising first and second coil springs, said first coil spring being associated with said first cylinder and having a first end axially fixed with respect to said piston rod and a second end axially fixed with respect to said first cylinder, said second coil spring being associated with said second cylinder and having a first end axially fixed with respect to said piston rod and a second end axially fixed with respect to said second cylinder.

6. The shock absorber of claim 5 wherein said first and second coil spring first ends are axially fixed with respect to said piston rod by means of an annular end plate fixed to said piston rod between said first and second cylinders.

7. The shock absorber of claim 1 wherein said shock absorber further comprises a sleeve extending between said first and second cylinders, said sleeve sealingly engaging said first and second cylinders so as to define a sleeve cavity therebetween, said sleeve being telescopically displaceable with respect to at least one of said first and second cylinders to allow for relative axial displacement of said first and second cylinders.

8. The shock absorber of claim 7 wherein said sleeve is provided with a valve means for adjusting gas pressure within said sleeve cavity.

9. The shock absorber of claim 7 wherein said sleeve is axially displaceable with respect to both of said first and second cylinders.

10. The shock absorber of claim 7 wherein a first annular cavity is defined in an overlap region between said first cylinder and said sleeve, opposing axial ends of said first annular cavity being respectively defined by a first seal means fixed to said first cylinder and sealingly engaging said sleeve and a second seal means fixed to said sleeve and sealingly engaging said first cylinder.

11. The shock absorber of claim 10 wherein said first annular cavity communicates with said first piston chamber, a cross-sectional area of said first annular cavity measured in a plane perpendicular to a longitudinal axis of said piston rod being substantially equal to a cross sectional area of said piston rod.

12. The shock absorber of claim 10 wherein said first annular cavity is provided with a valve means for adjusting gas pressure therein.

13. The shock absorber of claim 10 wherein a second annular cavity is defined in an overlap region between said second cylinder and said sleeve, opposing axial ends of said second annular cavity being respectively defined by a first seal means fixed to said second cylinder and sealingly engaging said sleeve and a second seal means fixed to said sleeve and sealingly engaging said second cylinder.

14. The shock absorber of claim 13 wherein said second annular cavity communicates with said second piston chamber, a cross-sectional area of said second annular cavity measured in a plane perpendicular to a longitudinal axis of said piston rod direction being substantially equal to a cross sectional area of said piston rod.

15. The shock absorber of claim 13 wherein said second annular cavity is provided with a valve means for adjusting gas pressure therein.

16. The shock absorber of claim 7 further comprising first and second coil springs, said first coil spring being associated with said first cylinder and having a first end axially fixed with respect to said sleeve and a second end axially fixed with respect to said first cylinder, said second coil spring being associated with said second cylinder and having a first end axially fixed with respect to sleeve and a second end axially fixed with respect to said second cylinder.

17. The shock absorber of claim 16 wherein said first and second coil spring first ends are axially fixed with respect to said sleeve by means of an annular end plate fixed to said sleeve between said first and second cylinders.

18. In combination, a first shock absorber according to claim 10 and a second shock absorber according to claim 10, wherein said first annular cavity of said first shock absorber is filled with liquid and is operatively associated with said sleeve cavity of said second shock absorber such that a decrease/increase in the volume of said first annular cavity of said first shock absorber provides an increase/decrease in gas pressure in said sleeve cavity of said second shock absorber.

19. The combination of claim 18 wherein said first annular cavity of said first shock absorber communicates with a first end of a control cylinder and said sleeve cavity of said second shock absorber communicates with a second end of said control cylinder, a control cylinder dividing piston being disposed within said control cylinder isolating said first annular cavity of said first shock absorber and said sleeve cavity of said second shock absorber.

20. The combination of claim 19 wherein said control cylinder dividing piston is provided with a piston rod sealingly received in a reduced cross section portion of said control cylinder toward said control cylinder first end such that an extending end of said piston rod isolates said first annular cavity of said first shock absorber.

21. The combination of claim 18 wherein the first annular cavity of said second shock absorber is filled with liquid and is operatively associated with said sleeve cavity of said first shock absorber such that a decrease/increase in the volume of said first annular

cavity of said second shock absorber provides an increase/decrease in gas pressure in said sleeve cavity of said second shock absorber.

22. A shock absorber comprising:

a cylinder having a liquid filled piston chamber,

first and second axially displaceable pistons received in said piston chamber towards first and second respective ends of said cylinder,

means for dampening axial displacement of each of said first and second pistons through said liquid in said piston chamber,

a first piston rod connected to said first piston and extending through said cylinder first end,

a second piston rod connected to said second piston and extending through said cylinder second end, and

means for securing said first and second piston rods to a body and wheel suspension of a vehicle, respectively.

23. The shock absorber of claim 22 wherein said piston chamber is divided into first and second sub-chambers by a sealed gas chamber, said gas chamber being separated from said first and second piston sub-chambers by axially displaceable dividing pistons, said first and second pistons being received in said first and second piston sub-chambers, respectively.

24. The shock absorber of claim 23 wherein said gas chamber is provided with a valve means for adjusting gas pressure therein.

25. The shock absorber of claim 22 wherein said piston chamber is divided into first and second sub-chambers by a fixed seal, said first and second pistons being received in said first and second piston sub-chambers, respectively.

26. The shock absorber of claim 25 wherein said first and second sub-chambers communicate with opposing ends of a gas cylinder via first and second conduits disposed adjacent said fixed seal in said first and second sub-chambers, respectively, said gas cylinder being provided with a gas chamber separated from said first and second conduits by axially displaceable dividing pistons.

27. The shock absorber of claim 22 further comprising first and second coil springs, said first coil spring being associated with said first piston rod and having a first end axially fixed with respect to said cylinder and a second end axially fixed with respect to said first piston rod, said second coil spring being associated with said second piston rod and having a first end axially fixed with respect to said cylinder and a second end axially fixed with respect to said second piston rod.

28. The shock absorber of claim 27 wherein said first and second coil spring first ends are axially fixed with respect to said cylinder by means of an annular end plate fixed to said cylinder.

29. The shock absorber of claim 22 further comprising a first sleeve telescopically disposed about and sealingly engaging said cylinder and extending from said cylinder first end, a distal axial end of said first sleeve being sealed such that said first sleeve defines a sealed first sleeve cavity, said first piston rod being fixed in relation to said first sleeve.

30. The shock absorber of claim 29 wherein said first sleeve is provided with a valve means for adjusting gas pressure within said first sleeve cavity.

31. The shock absorber of claim 29 wherein a first annular cavity is defined in an overlap region between said cylinder and said first sleeve, opposing axial ends of said annular cavity being respectively defined by a first seal means fixed to said cylinder and sealingly engaging said first sleeve and a second seal means fixed to said first sleeve and sealingly engaging said cylinder.

32. The shock absorber of claim 31 wherein said first annular cavity communicates with said first piston sub-chamber, a cross sectional area of said first annular cavity measured in a plane perpendicular to a longitudinal axis of said first piston rod being substantially equal to a cross sectional area of said first piston rod.

33. The shock absorber of claim 31 wherein said first annular cavity is provided with a valve means for adjusting gas pressure therein.

34. The shock absorber of claim 29 further comprising a second sleeve telescopically disposed about and sealingly engaging said cylinder and extending from said cylinder second end, a distal axial end of said second sleeve being sealed such that

said second sleeve defines a sealed second sleeve cavity. said second piston rod being fixed in relation to said second sleeve.

35. The shock absorber of claim 34 wherein said second sleeve is provided with a valve means for adjusting gas pressure within said second sleeve cavity.

36. The shock absorber of claim 35 wherein a second annular cavity is defined in an overlap region between said cylinder and said second sleeve. opposing axial ends of said annular cavity being respectively defined by a first seal means fixed to said cylinder and sealingly engaging said second sleeve and a second seal means fixed to said second sleeve and sealingly engaging said cylinder.

37 The shock absorber of claim 36 wherein said second sealed annular cavity communicates with said second piston sub-chamber, a cross sectional area of said first sealed annular cavity measured in a plane perpendicular to a longitudinal axis of said second piston rod being substantially equal to a cross sectional area of said second piston rod.

38. The shock absorber of claim 36 wherein said second sealed annular cavity is provided with a valve means for adjusting gas pressure therein.

39. In combination. a first shock absorber according to claim 31 and a second shock absorber according to claim 31 wherein said first annular cavity of said first shock absorber is filled with liquid and is operatively associated with said first sleeve cavity of said second shock absorber such that a decrease/increase in the volume of said first annular cavity of said first shock absorber provides an increase/decrease in gas pressure in said first sleeve cavity of said second shock absorber.

40. The combination of claim 39 wherein said first annular cavity of said first shock absorber communicates with a first end of a control cylinder and said first sleeve cavity of said second shock absorber communicates with a second end of said control cylinder, a control cylinder dividing piston being disposed within said control cylinder isolating said first annular cavity of said first shock absorber and said first sleeve cavity of said second shock absorber.

41. The combination of claim 40 wherein said control cylinder dividing piston is provided with a piston rod sealingly received in a reduced cross section portion of said

control cylinder toward said control cylinder first end such that an extending end of said piston rod isolates said first annular cavity of said first shock absorber.

42. The combination of claim 39 wherein the first annular cavity of said second shock absorber is filled with liquid and is operatively associated with said first sleeve cavity of said first shock absorber such that a decrease/increase in the volume of said first annular cavity of said second shock absorber provides an increase/decrease in gas pressure in said first sleeve cavity of said first shock absorber.

43. A shock absorber comprising:

a cylinder having a liquid filled piston chamber,

an axially displaceable piston received in said piston chamber,

means for dampening axial displacement of said piston through said liquid in said piston chamber,

a piston rod connected to said piston and extending through a first end of said cylinder,

a sleeve telescopically disposed about and sealingly engaging said cylinder and extending from said cylinder first end, a distal axial end of said sleeve being sealed such that said sleeve defines a sealed sleeve cavity, said piston rod being fixed in relation to said sleeve, and,

means for securing one of said sleeve and said cylinder to a body of a vehicle and the other of said sleeve and said cylinder to a wheel suspension of a vehicle.

44. The shock absorber of claim 43 wherein said sleeve is provided with a valve means for adjusting gas pressure within said sleeve cavity.

45. The shock absorber of claim 43 wherein an annular cavity is defined in an overlap region between said cylinder and said sleeve, opposing axial ends of said annular cavity being respectively defined by a first seal means fixed to said cylinder and sealingly engaging said sleeve and a second seal means fixed to said sleeve and sealingly engaging said cylinder.

46. The shock absorber of claim 45 wherein said annular cavity communicates with said piston chamber, a cross sectional area of said annular cavity measured in a plane

perpendicular to a longitudinal axis of said piston rod being substantially equal to a cross sectional area of said piston rod.

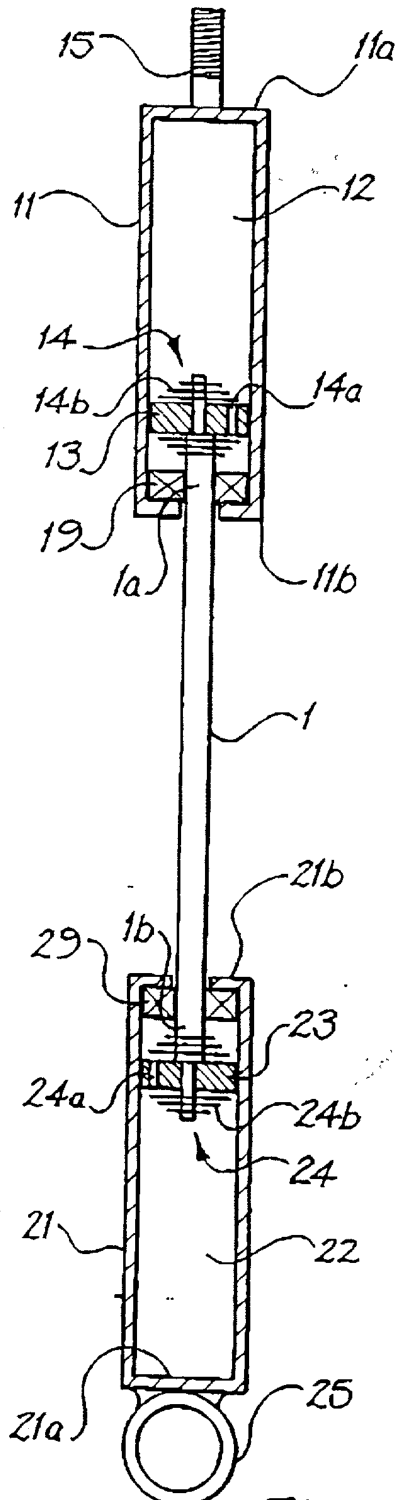
47. The shock absorber of claim 45 wherein said annular cavity is provided with a valve means for adjusting gas pressure therein.

48. In combination, a first shock absorber according to claim 45 and a second shock absorber according to claim 45 wherein said annular cavity of said first shock absorber is filled with liquid and is operatively associated with said sleeve cavity of said second shock absorber such that a decrease/increase in the volume of said annular cavity of said first shock absorber provides an increase/decrease in gas pressure in said sleeve cavity of said second shock absorber.

49. The combination of claim 48 wherein said annular cavity of aid first shock absorber communicates with a first end of a control cylinder and said sleeve cavity of said second shock absorber communicates with a second end of said control cylinder. a control cylinder dividing piston being disposed within said control cylinder isolating said annular cavity of said first shock absorber and said sleeve cavity of said second shock absorber.

50. The combination of claim 49 wherein said control cylinder dividing piston is provided with a piston rod sealingly received in a reduced cross section portion of said control cylinder toward said control cylinder first end such that an extending end of said piston rod isolates said annular cavity of said first shock absorber.

51. The combination of claim 48 wherein said annular cavity of said second shock absorber is filled with liquid and is operatively associated with said sleeve cavity of said first shock absorber such that a decrease/increase in the volume of said annular cavity of said second shock absorber provides an increase/decrease in gas pressure in said sleeve cavity of said first shock absorber.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24b
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21a
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FIG. 1

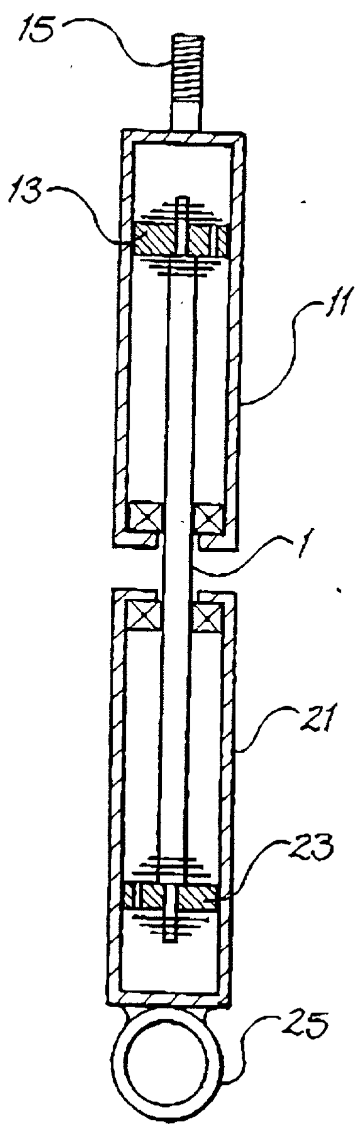
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FIG. 2

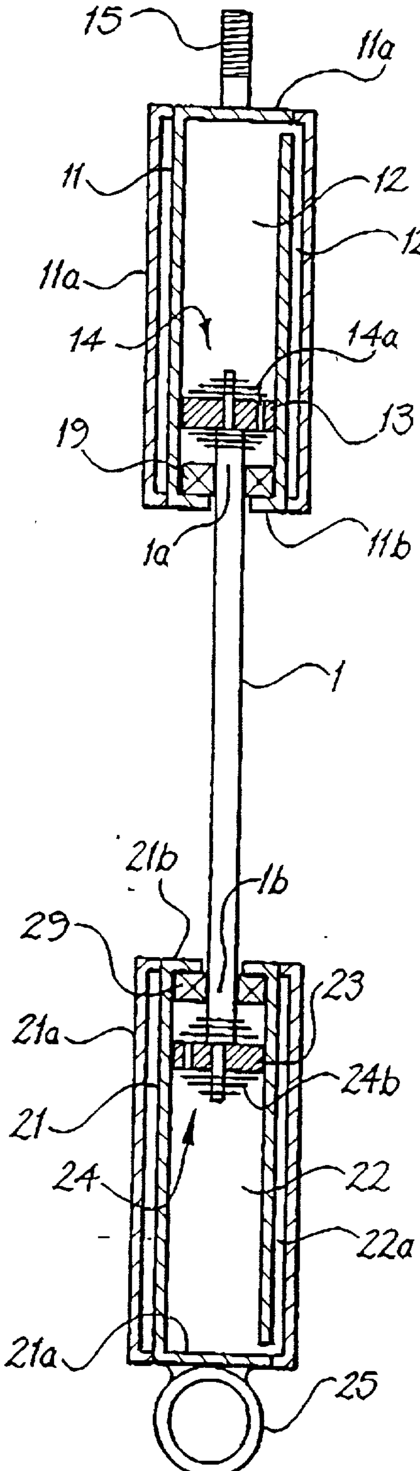
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FIG. 1a

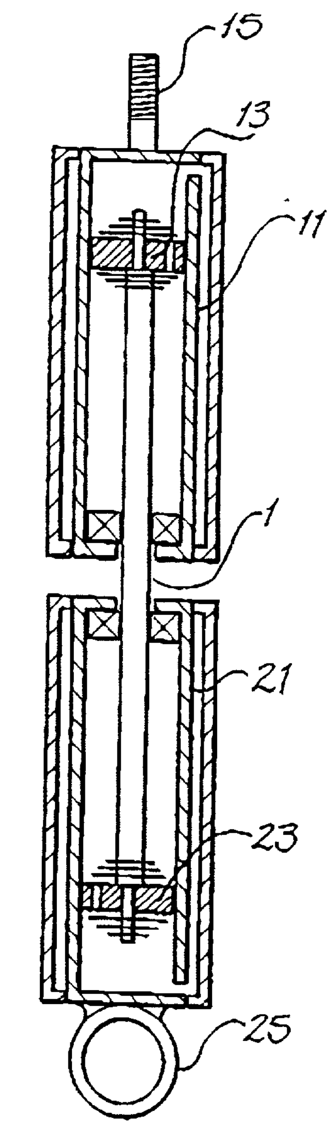
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FIG. 2a

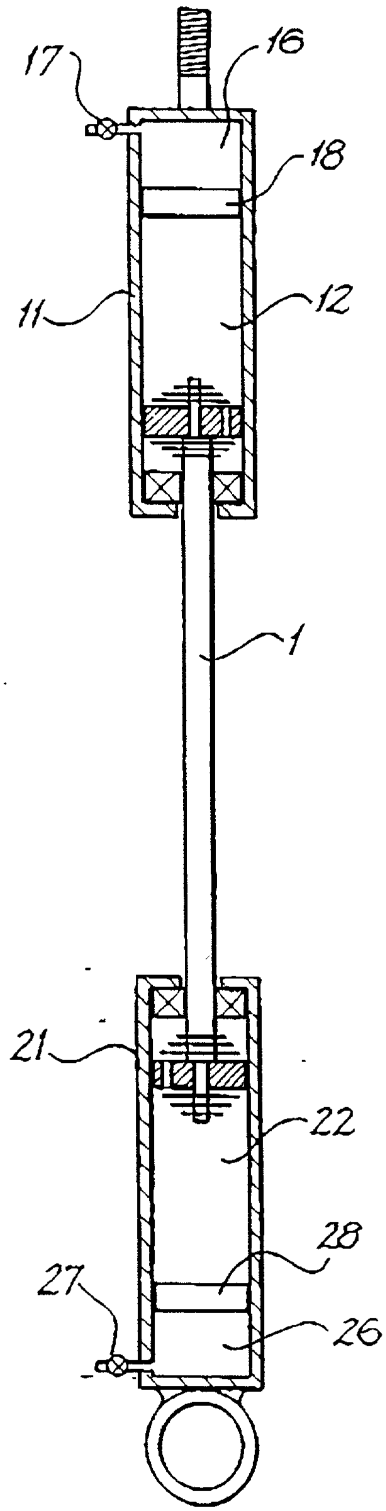


FIG. 3

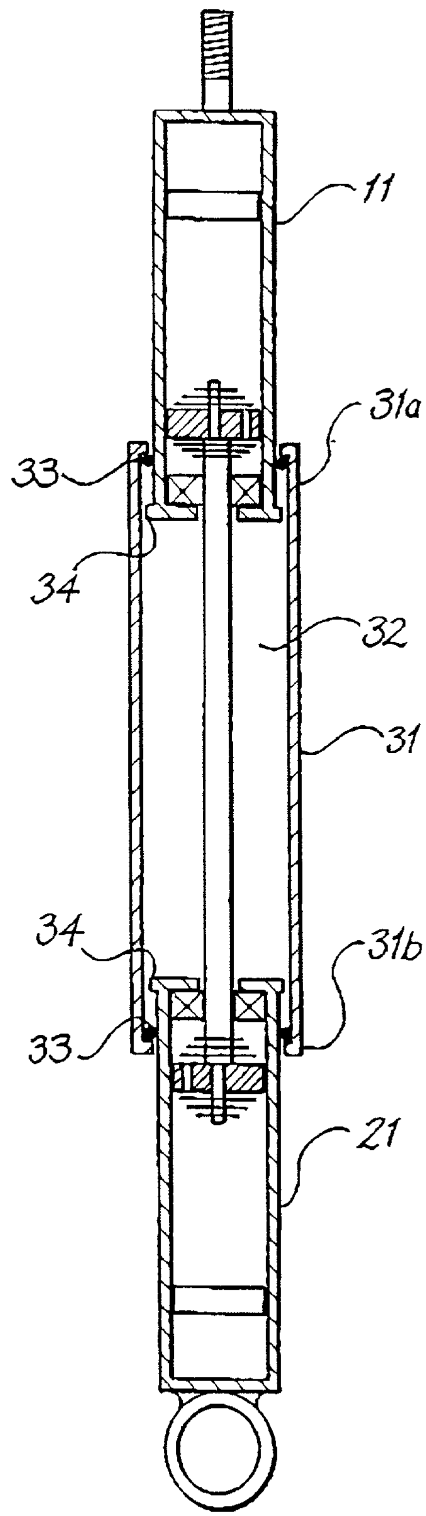


FIG. 4

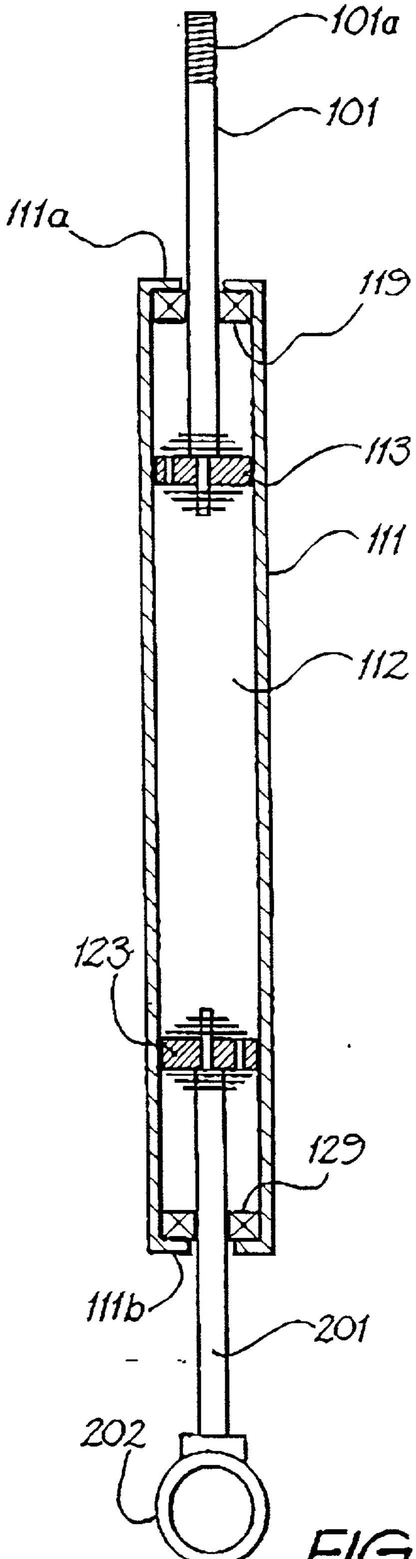
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FIG. 5

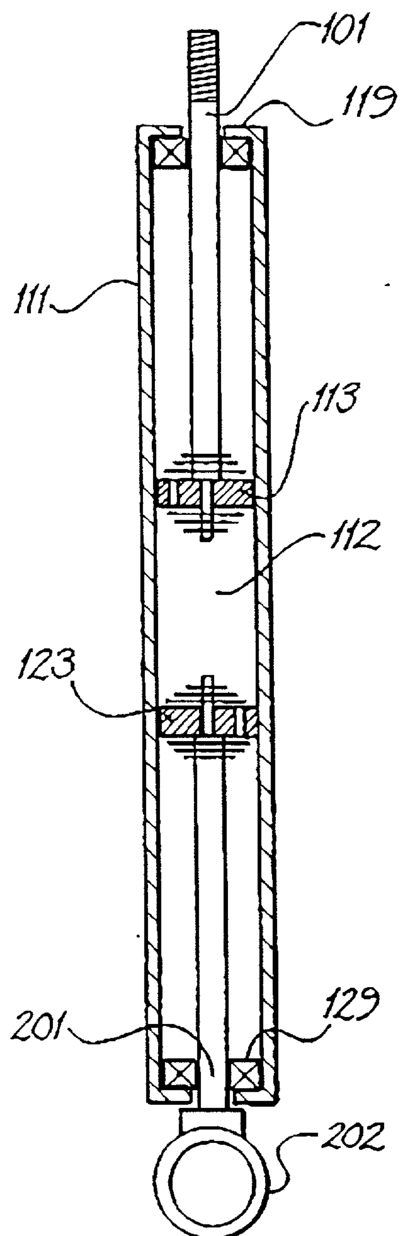
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FIG. 6

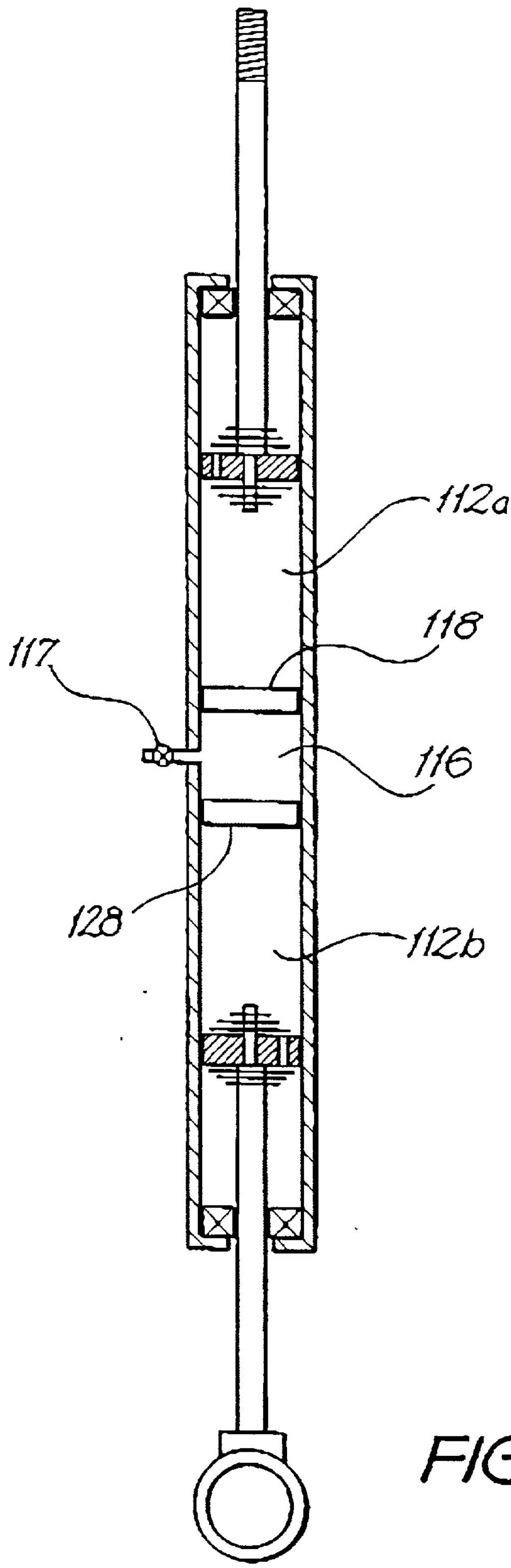


FIG. 7

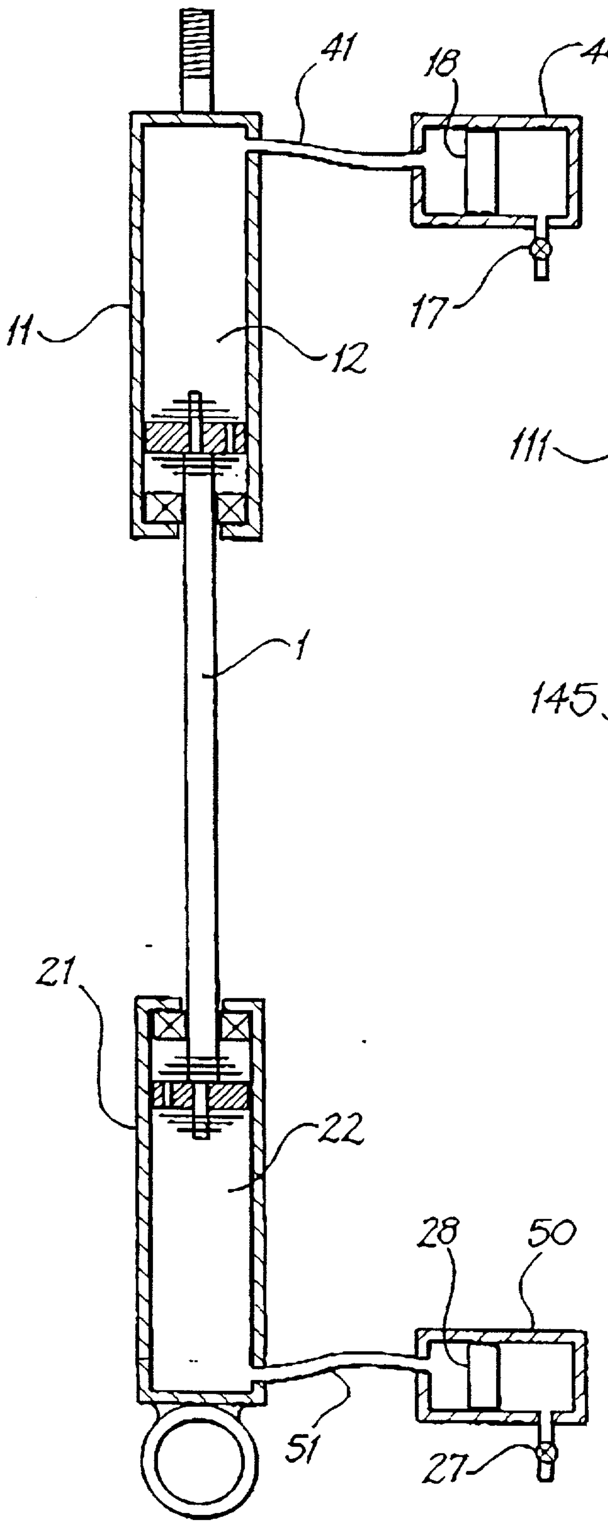
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FIG. 8

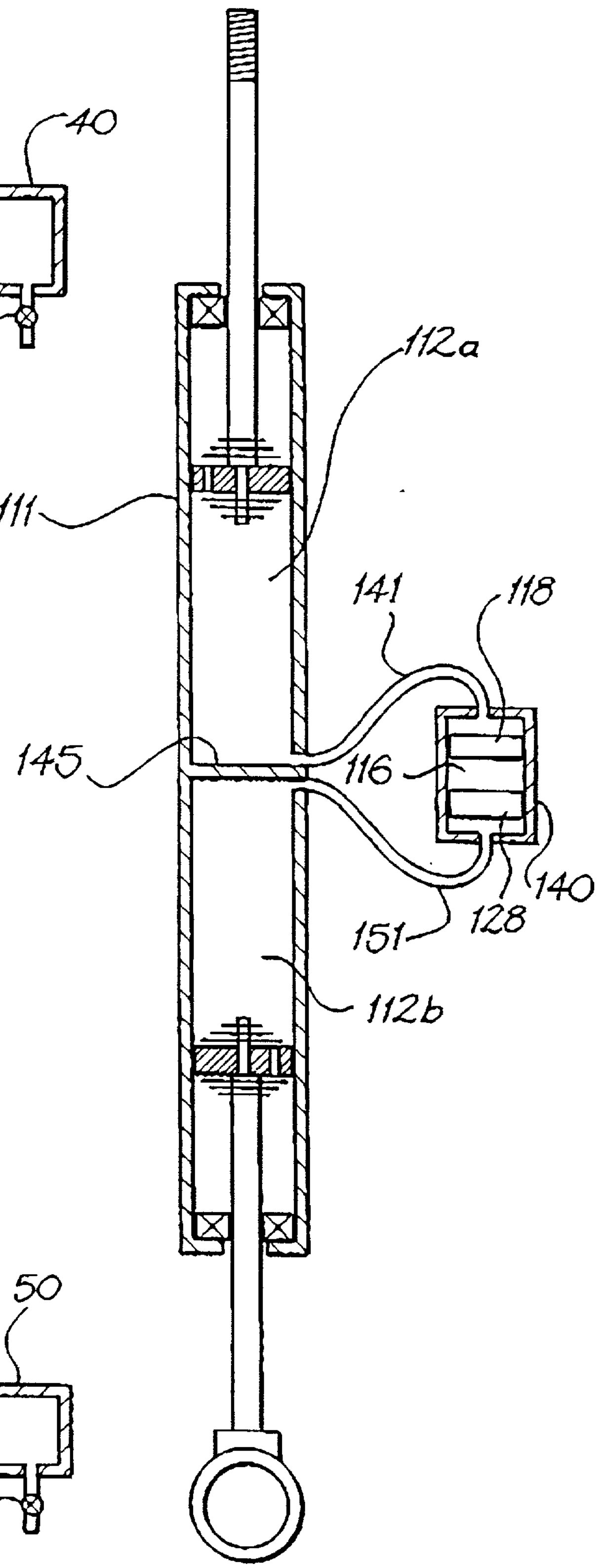
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FIG. 9

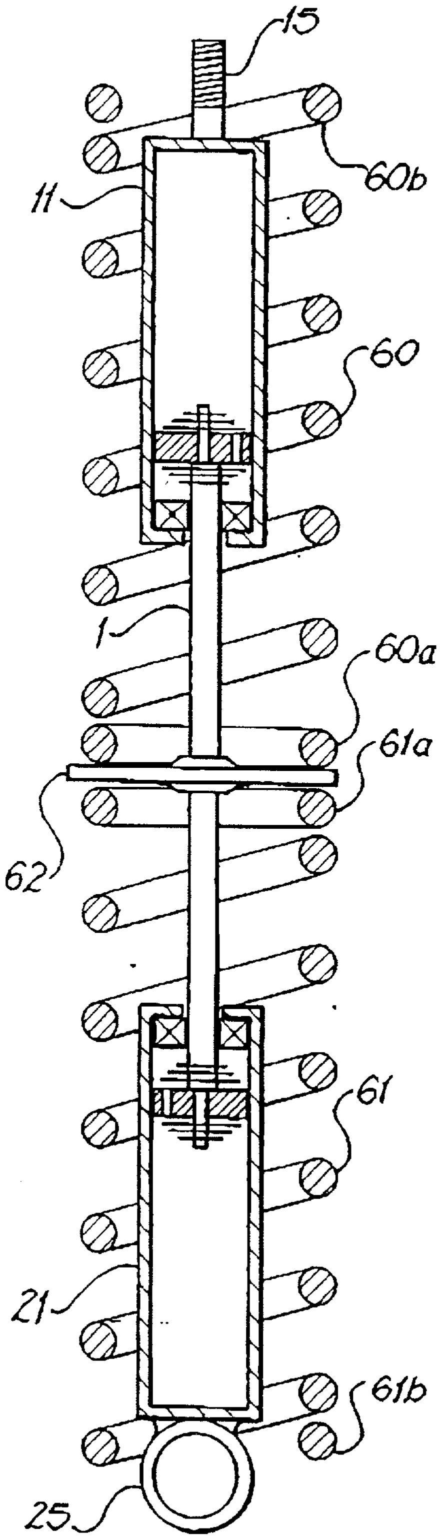
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FIG. 10

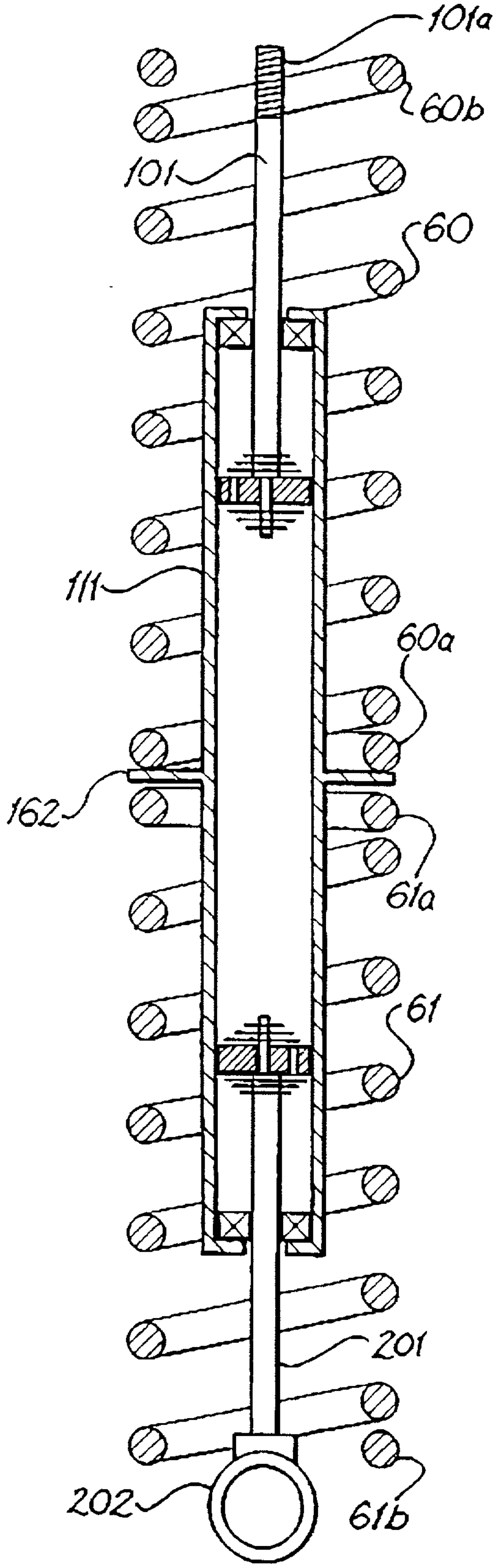
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FIG. 11

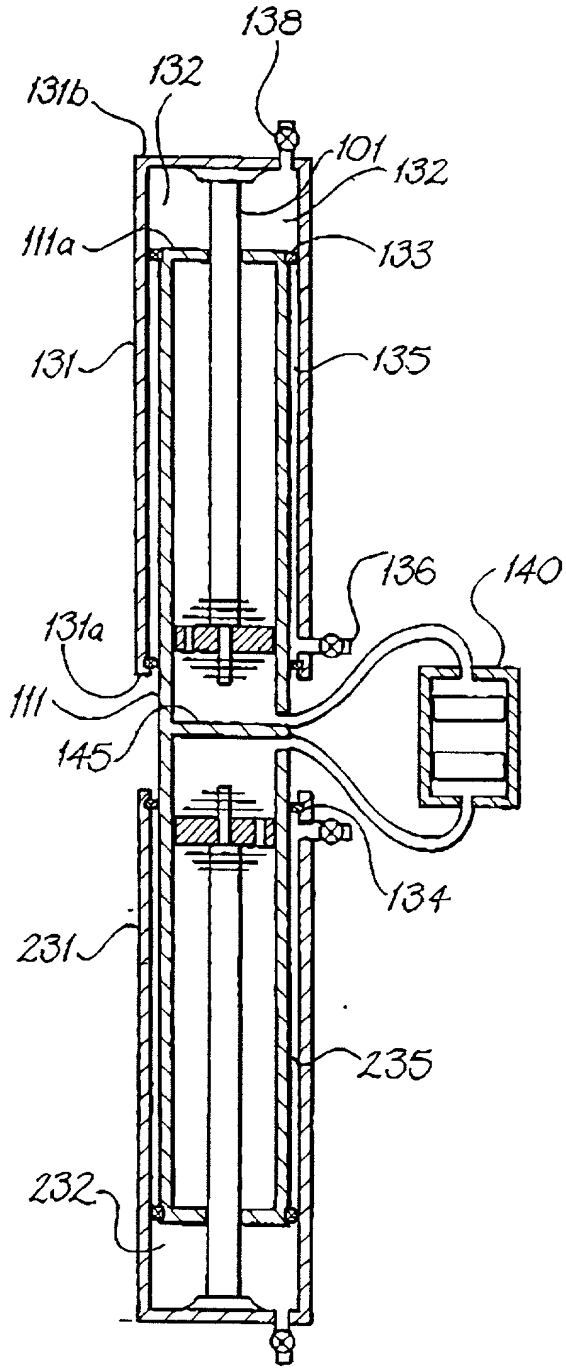
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FIG. 12

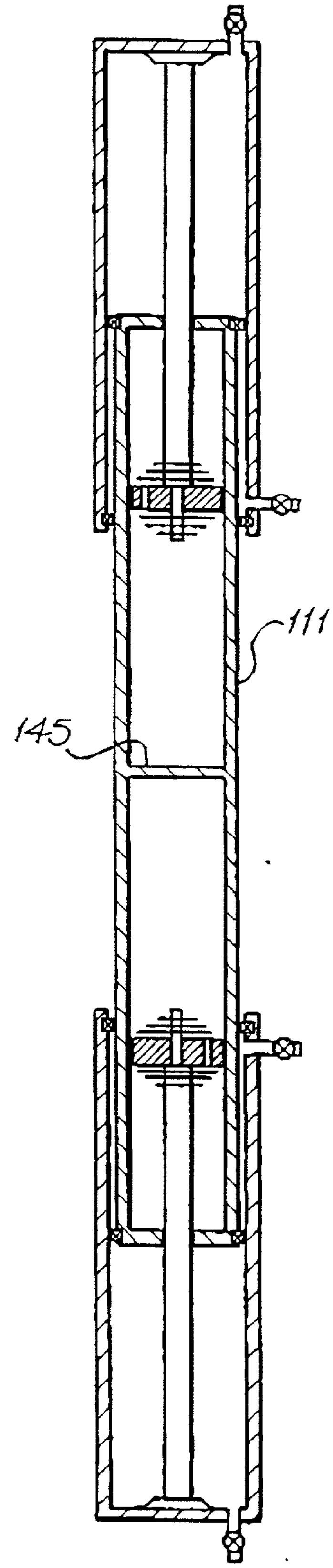
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FIG. 13

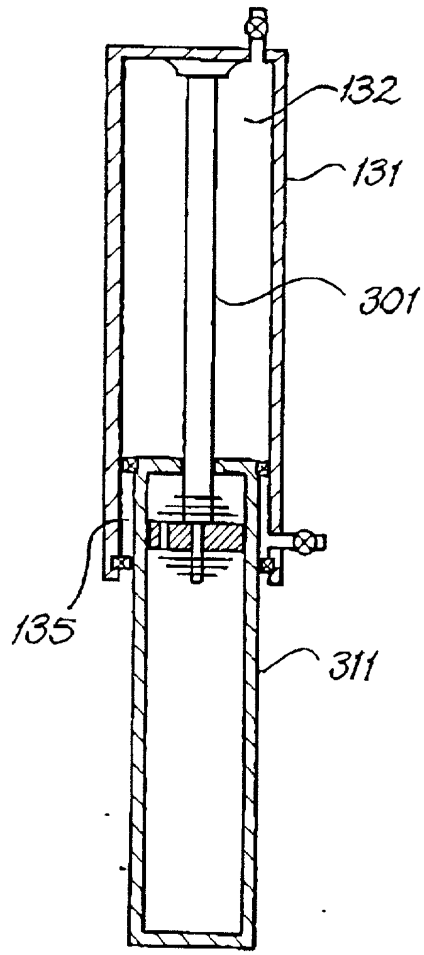


FIG. 14

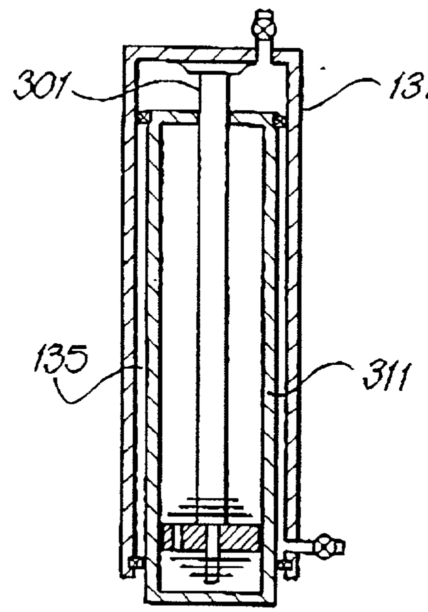


FIG. 15

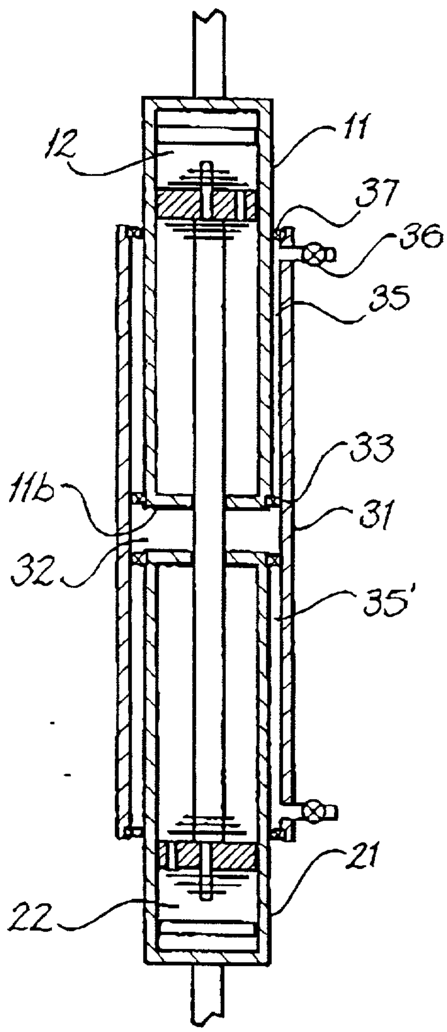


FIG. 16

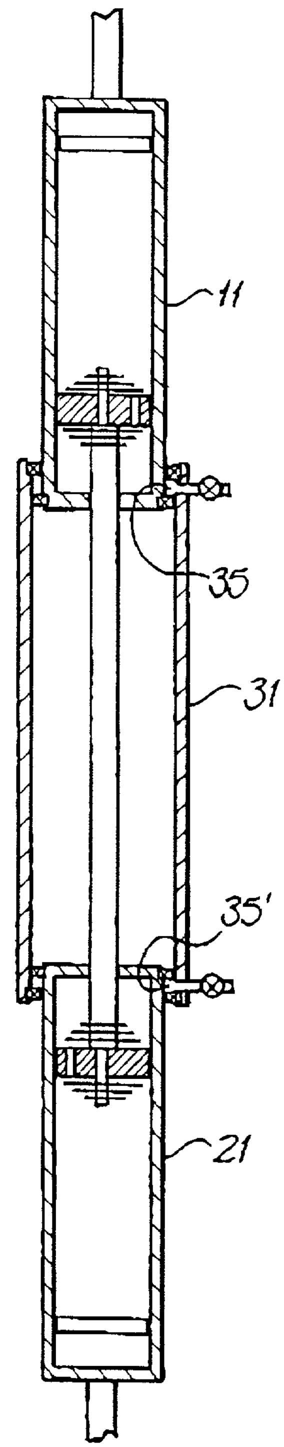


FIG. 17

Inventor: Richard BUGAJ
Docket No.: 3961.47USWO
Title: SHOCK ABSORBER
Attorney Name: Brian H. Batzli (Reg. No. 32,960)
Sheet 11 of 16



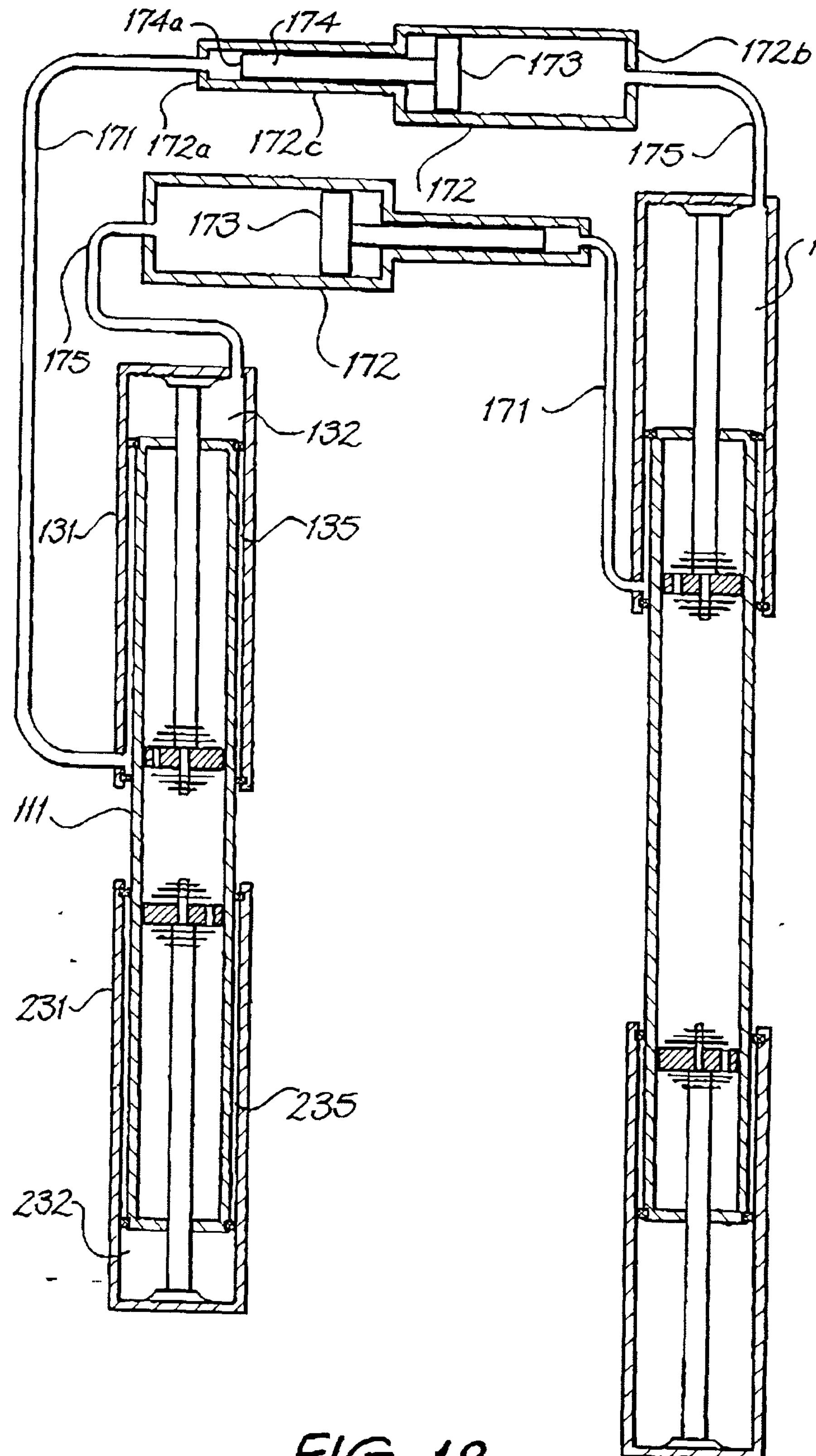


FIG. 18

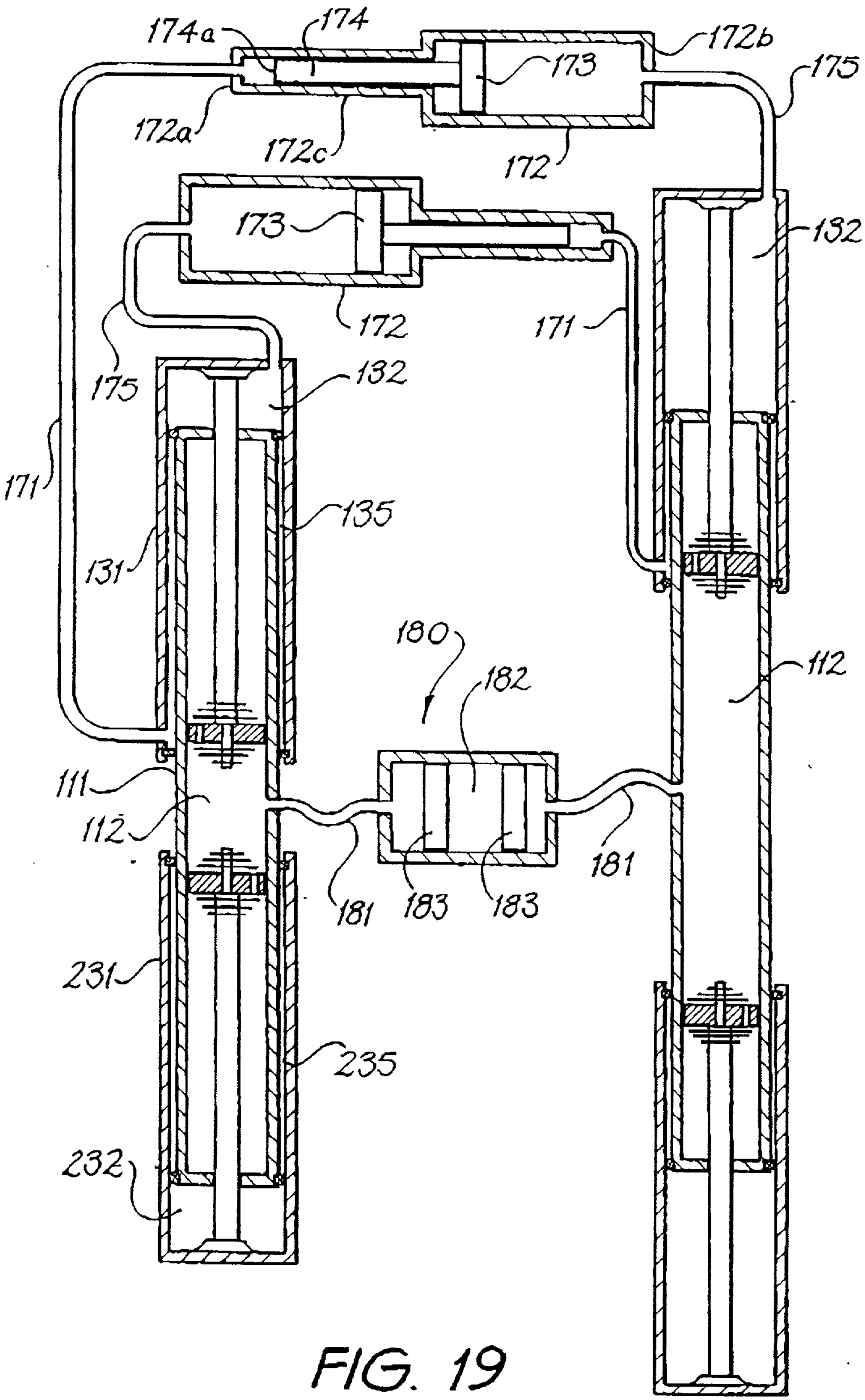
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FIG. 19

Inventor: Richard BUGAJ
Docket No.: 3961.47USWO
Title SHOCK ABSORBER
Attorney Name: Brian H. Batzli (Reg No. 32,960)
Sheet 13 of 16

09/868462



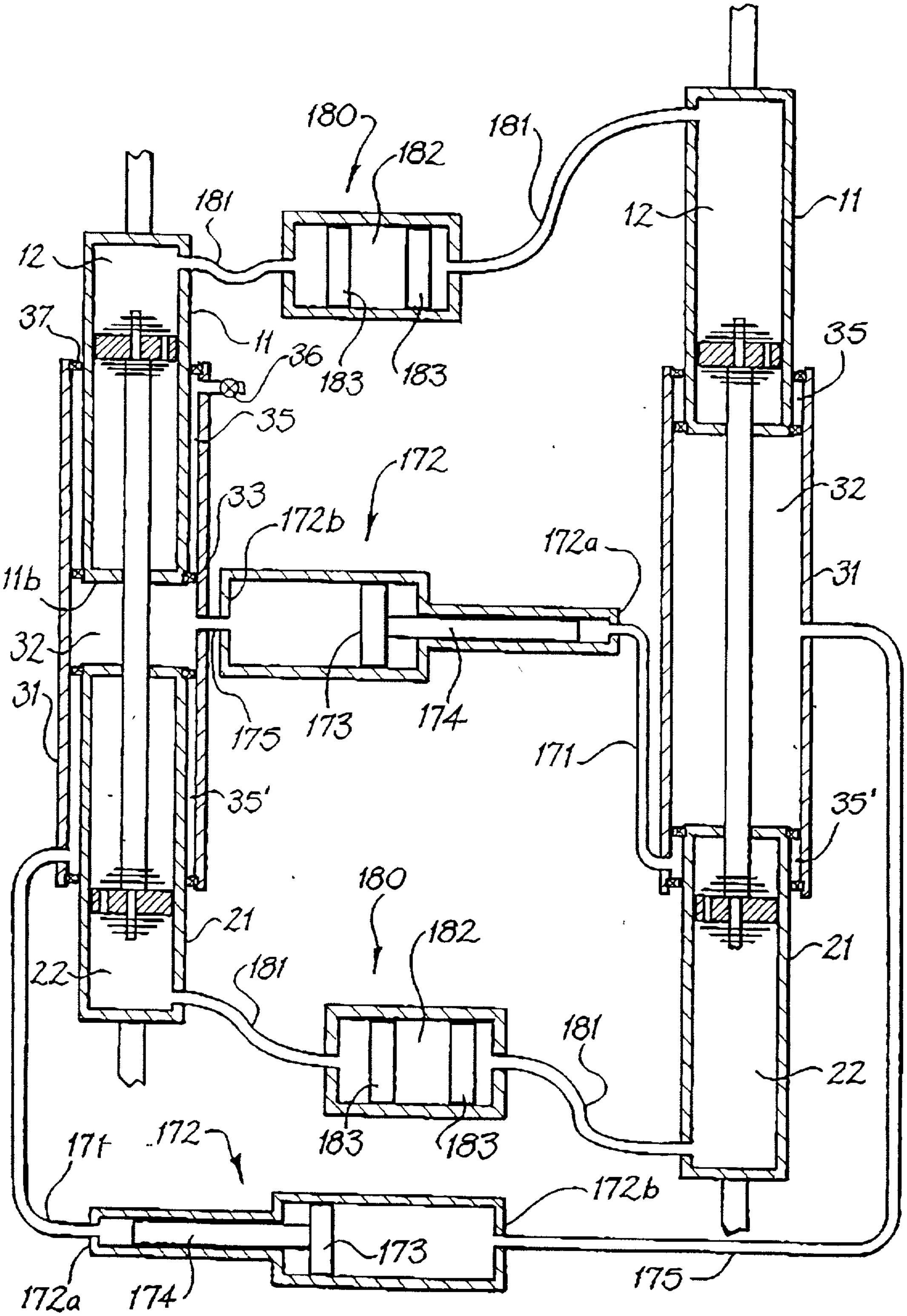


FIG. 20

WO 00/37822 PCT/AU99/01127 09/868462



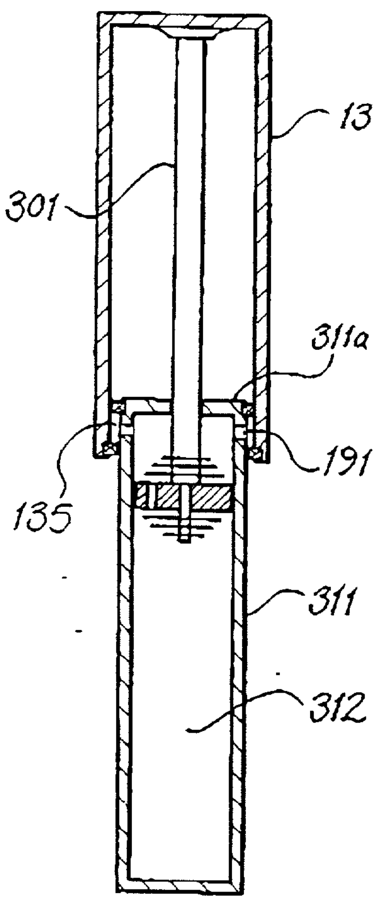


FIG. 21

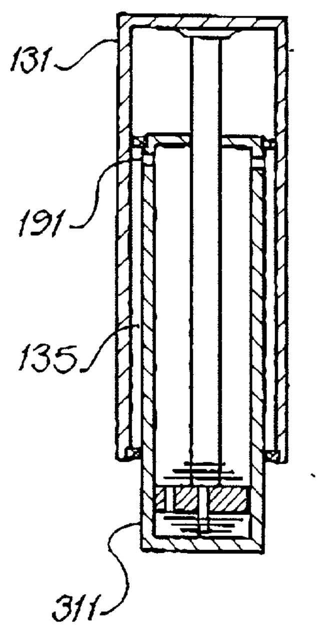


FIG. 22

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PCT/AU99/01127



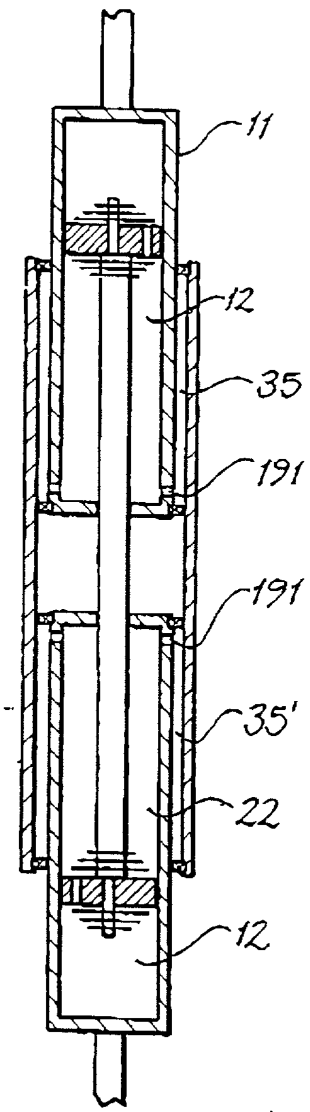


FIG. 23

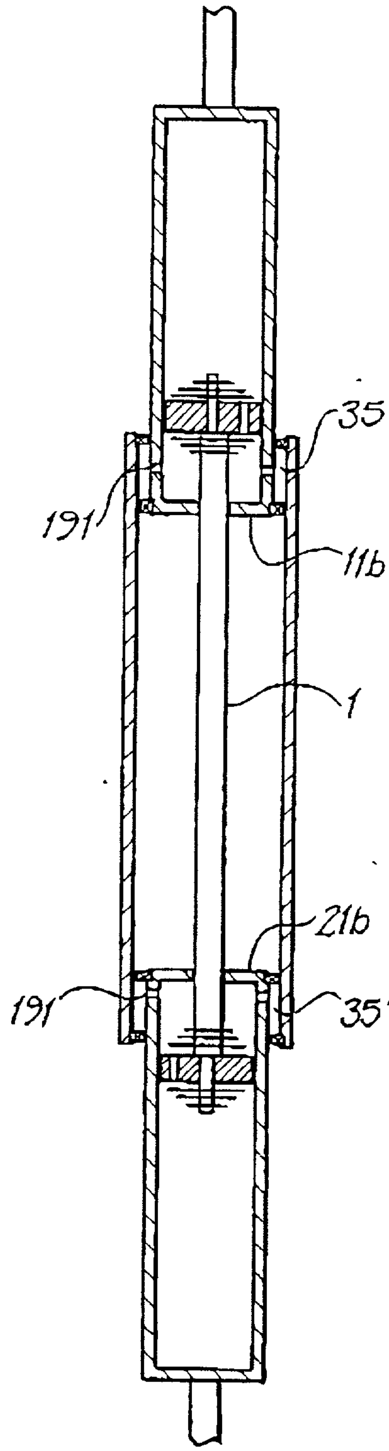


FIG. 24

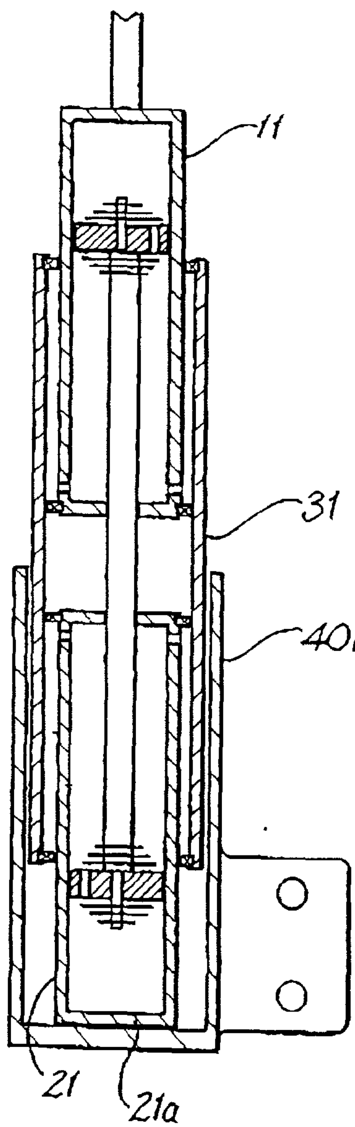


FIG. 25

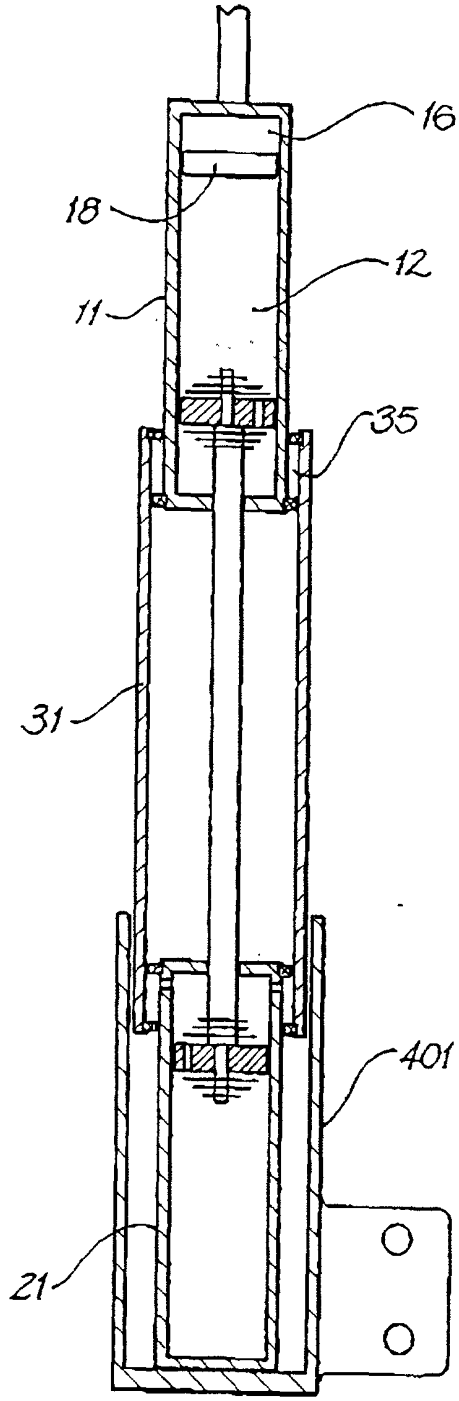


FIG. 26

Attorney Docket No. 3961.47USWO

MERCHANT & GOULD P.C.

**United States Patent Application**

**COMBINED DECLARATION AND POWER OF ATTORNEY**



As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: SHOCK ABSORBER

The specification of which
a. ☐ is attached hereto
b. ☒ was filed on 18 June 2001 as application serial no. 09/868462 and was amended on (if applicable) (in the case of a PCT-filed application) described and claimed in international no. PCT/AU99/01127 filed 17 December 1999 and as amended on 19 October 2000 (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

a. ☐ no such applications have been filed.
b. ☒ such applications have been filed as follows:

| **FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119** | | | |
|---|---|---|---|
| **COUNTRY** | **APPLICATION NUMBER** | **DATE OF FILING (day, month, year)** | **DATE OF ISSUE (day, month, year)** |
| Australia | PP 7796 | 18 December 1998 | |
| Australia | PP 9839 | 19 April 1999 | |

| **ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)** | | | |
|---|---|---|---|
| **COUNTRY** | **APPLICATION NUMBER** | **DATE OF FILING (day, month, year)** | **DATE OF ISSUE (day, month, year)** |
| | | | |

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

| **U.S. APPLICATION NUMBER** | **DATE OF FILING (day, month, year)** | **STATUS (patented, pending, abandoned)** |
|---|---|---|
| | | |

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

| **U.S. PROVISIONAL APPLICATION NUMBER** | **DATE OF FILING** (Day, Month, Year) |
|---|---|
| | |

I acknowledge the duty to disclose information that is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (reprinted below):

**§ 1.56 Duty to disclose information material to patentability.**

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application:

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

(e) In any continuation-in-part application, the duty under this section includes the duty to disclose to the Office all information known to the person to be material to patentability, as defined in paragraph (b) of this section, which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

| | | | |
|---|---|---|---|
| Albrecht, John W. | Reg. No. 40,481 | Leonard, Christopher J. | Reg. No. 41,940 |
| Ali, M. Jeffer | Reg. No. 46,359 | Liepa, Mara E. | Reg. No. 40,066 |
| Anderson, Gregg I. | Reg. No. 28,828 | Lindquist, Timothy A. | Reg. No. 40,701 |
| Batzli, Brian H. | Reg. No. 32,960 | Mayfield, Denise L. | Reg. No. 33,732 |
| Beard, John L. | Reg. No. 27,612 | McDonald, Daniel W. | Reg. No. 32,044 |
| Berns, John M. | Reg. No. 43,496 | McIntyre, Jr., William F. | Reg. No. 44,921 |
| Black, Bruce E. | Reg. No. 41,622 | Mitchem, M. Todd | Reg. No. 40,731 |
| Branch, John W. | Reg. No. 41,633 | Mueller, Douglas P. | Reg. No. 30,300 |
| Bremer, Dennis C. | Reg. No. 40,528 | Nichols, A. Shane | Reg. No. 43,836 |
| Bruess, Steven C. | Reg. No. 34,130 | Parsons, Nancy J. | Reg. No. 40,364 |
| Byrne, Linda M. | Reg. No. 32,404 | Pauly, Daniel M. | Reg. No. 40,123 |
| Campbell, Keith | Reg. No. 46,597 | Phillips, John B. | Reg. No. 37,206 |
| Carlson, Alan G. | Reg. No. 25,959 | Prendergast, Paul | Reg. No. 46,068 |
| Caspers, Philip P. | Reg. No. 33,227 | Pytel, Melissa J. | Reg. No. 41,512 |
| Clifford, John A. | Reg. No. 30,247 | Qualey, Terry | Reg. No. 25,148 |
| Coldren, Richard J | Reg. No 44,084 | Reich, John C. | Reg. No. 37,703 |
| Daignault, Ronald A. | Reg. No. 25,968 | Reiland, Earl D. | Reg. No. 25,767 |
| Daley, Dennis R. | Reg. No. 34,994 | Roberts, Fred | Reg. No. 34,707 |
| Dalglish, Leslie E. | Reg. No. 40,579 | Samuels, Lisa A. | Reg. No. 43,080 |
| Daulton, Julie R. | Reg. No. 36,414 | Schmaltz, David G. | Reg. No. 39,828 |
| DeVries Smith, Katherine M. | Reg. No. 42,157 | Schuman, Mark D. | Reg. No. 31,197 |
| DiPietro, Mark J. | Reg. No. 28,707 | Schumann, Michael D. | Reg. No. 30,422 |
| Doscotch, Matthew A. | Reg No. P48,957 | Scull, Timothy B. | Reg. No. 42,137 |
| Edell, Robert T. | Reg. No. 20,187 | Sebald, Gregory A. | Reg. No. 33,280 |
| Epp Ryan, Sandra | Reg. No. 39,667 | Skoog, Mark T. | Reg. No. 40,178 |
| Glance, Robert J. | Reg. No. 40,620 | Spellman, Steven J. | Reg. No. 45,124 |
| Goggin, Matthew J. | Reg. No. 44,125 | Stoll-DeBell, Kirstin L. | Reg. No. 43,164 |
| Golla, Charles E. | Reg. No. 26,896 | Sullivan, Timothy | Reg. No. 47,981 |
| Gorman, Alan G. | Reg. No. 38,472 | Sumner, John P. | Reg. No. 29,114 |
| Gould, John D. | Reg. No. 18,223 | Swenson, Erik G. | Reg. No. 45,147 |
| Gregson, Richard | Reg. No. 41,804 | Tellekson, David K. | Reg. No. 32,314 |
| Gresens, John J. | Reg. No. 33,112 | Trembath, Jon R. | Reg. No. 38,344 |
| Hamer, Samuel A. | Reg. No. 46,754 | Tunheim, Marcia A | Reg. No. 42,189 |
| Hamre, Curtis B. | Reg. No. 29,165 | Underhill, Albert L. | Reg. No. 27,403 |
| Harrison, Kevin C. | Reg. No. 46,759 | Vandenburgh, J. Derek | Reg. No. 32,179 |
| Hertzberg, Brett A. | Reg. No. 42,660 | Wahl, John R. | Reg. No. 33,044 |
| Hillson, Randall A. | Reg. No. 31,838 | Weaver, Karrie G. | Reg. No. 43,245 |
| Holzer, Jr., Richard J. | Reg. No. 42,668 | Welter, Paul A. | Reg. No. 20,890 |
| Johnston, Scott W. | Reg. No. 39,721 | Whipps, Brian | Reg. No. 43,261 |
| Kadievitch, Natalie D. | Reg. No. 34,196 | Whitaker, John E. | Reg. No. 42,222 |
| Karjeker, Shaukat | Reg. No. 34,049 | Williams, Douglas J. | Reg. No. 27,054 |
| Kettelberger, Denise | Reg. No. 33,924 | Withers, James D. | Reg. No. 40,376 |
| Keys, Jeramie J. | Reg. No. 42,724 | Witt, Jonelle | Reg. No. 41,980 |
| Knearl, Homer L. | Reg. No. 21,197 | Wu, Tong | Reg. No. 43,361 |
| Kowalchyk, Alan W. | Reg. No. 31,535 | Xu, Min S. | Reg. No. 39,536 |
| Kowalchyk, Katherine M. | Reg. No. 36,848 | Young, Thomas | Reg. No. 25,796 |
| Lacy, Paul E. | Reg. No. 38,946 | Zeuli, Anthony R. | Reg. No. 45,255 |
| Larson, James A. | Reg. No. 40,443 | | |
| Leon, Andrew J. | Reg. No. 46,869 | | |

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould P.C. to the contrary.

I understand that the execution of this document, and the grant of a power of attorney, does not in itself establish an attorney-client relationship between the undersigned and the law firm Merchant & Gould P.C., or any of its attorneys.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below:

Merchant & Gould P.C.
P.O. Box 2903
Minneapolis, MN 55402-0903

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PATENT TRADEMARK OFFICE

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false stateme may jeopardize the validity of the application or any patent issued thereon.

| | | | | |
|---|---|---|---|---|
| 2 | Full Name Of Inventor | Family Name BUGAJ | First Given Name Richard | Second Given Name |
| 0 | Residence & Citizenship | City Rosemeadow NSW AUX | State or Foreign Country Australia | Country of Citizenship Australia |
| 1 | Mailing Address | Address 14 Lorenzo Crescent | City Rosemeadow | State & Zip Code/Country New South Wales 2560 / Australia |
| | Signature of Inventor 201: | Richard Bugaj | | Date: 7 August 2001 |